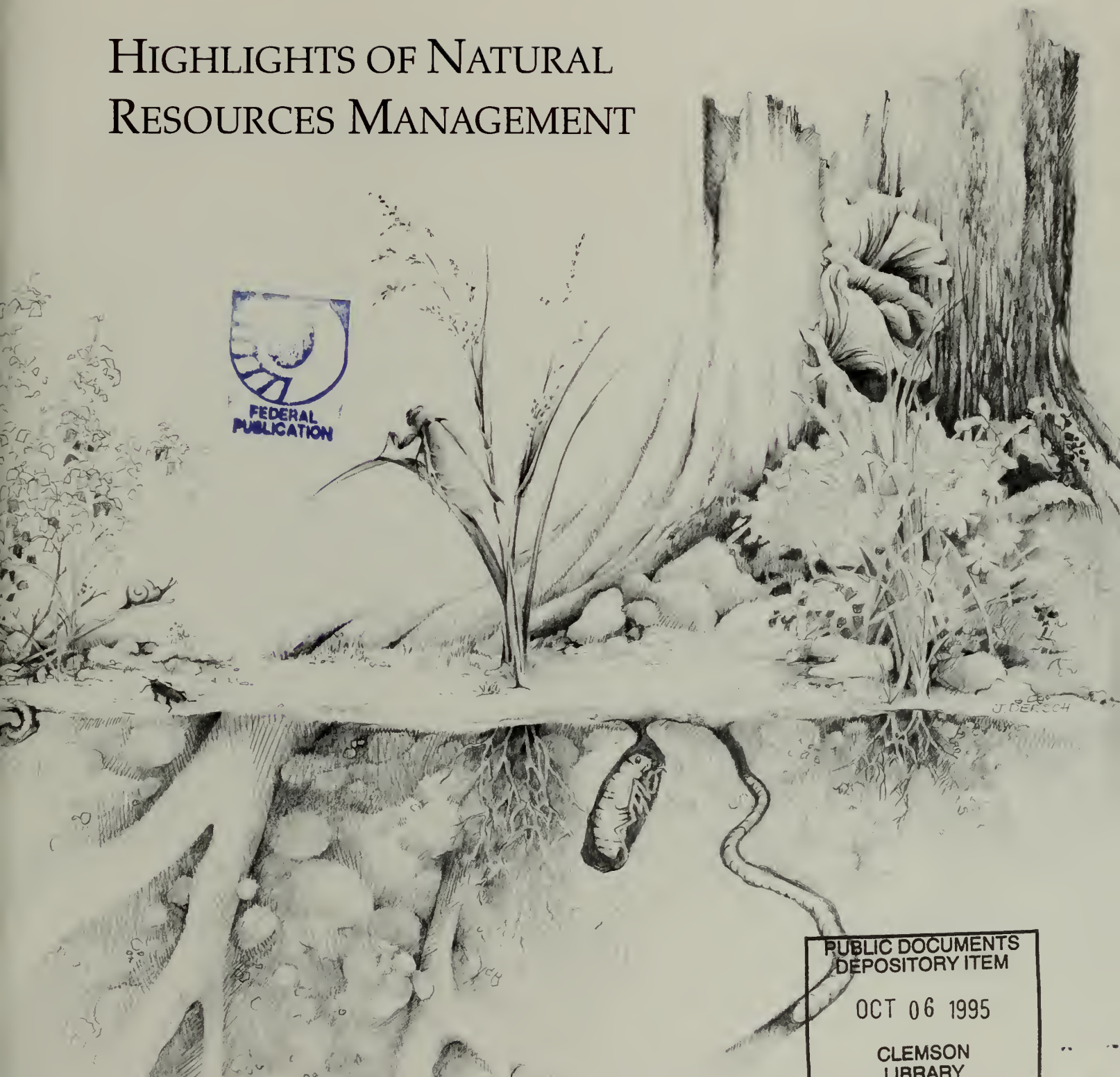
HIGHLIGHTS OF NATURAL RESOURCES MANAGEMENT



1994

Natural Resources Report NPS / NRPO / NRR-95 / 18
United States Department of the Interior
National Park Service

Highlights of Natural Resources Management

A Report on National Park Service Natural Resources Management Activities in 1994

For additional copies:

Publications Coordinator
National Park Service
Natural Resources Publication Office
P.O. Box 25287
Denver, CO 80225-0287

Highlights of Natural Resources Management

Natural Resources Report NPS/NRPO/NRR-95/18

United States Department of the Interior
National Park Service
Natural Resources Publication Office

Table of Contents

Step 3 — RESTORE Resources to Their Natural Condition and Function

Step 4 — PROTECT Resources and Natural Systems

NRPP Makes a Difference in Resource Management

The Public Helps Us Protect Resources

NPS Units Represented in the Highlights of Natural Resources Management Report / 46

Big Steps

Landmark Water Rights Agreement Protects Yellowstone's Hydrothermal Features

By Mary Hektner, Natural Resource Management Specialist, Yellowstone National Park, and Chuck Pettee, Hydrologist, Water Rights Branch, Water Resources Division

Yellowstone National Park's world-famous geysers and hot springs will now be the most protected of their type in the world. After a decade of negotiations with the Montana's Reserved Water Rights Compact Commission, a water rights agreement between the National Park Service and Montana provides unprecedented protection for the park's extensive hydrothermal system.

Thermal groundwater systems, or hydrothermal systems, are characterized by complex combinations of water pressure, temperature, and flow pathways. Altering any of these three components can have far-reaching ramifications. Surface features may respond to relatively small changes in subsurface reservoir pressure, temperature, and flow pathways at distances as great as 6 miles. Additionally, changes in these reservoir characteristics may take many years to manifest themselves at a surface feature. Experience has shown that once a change occurs, there is little chance that removing the cause will fully restore the surface feature.

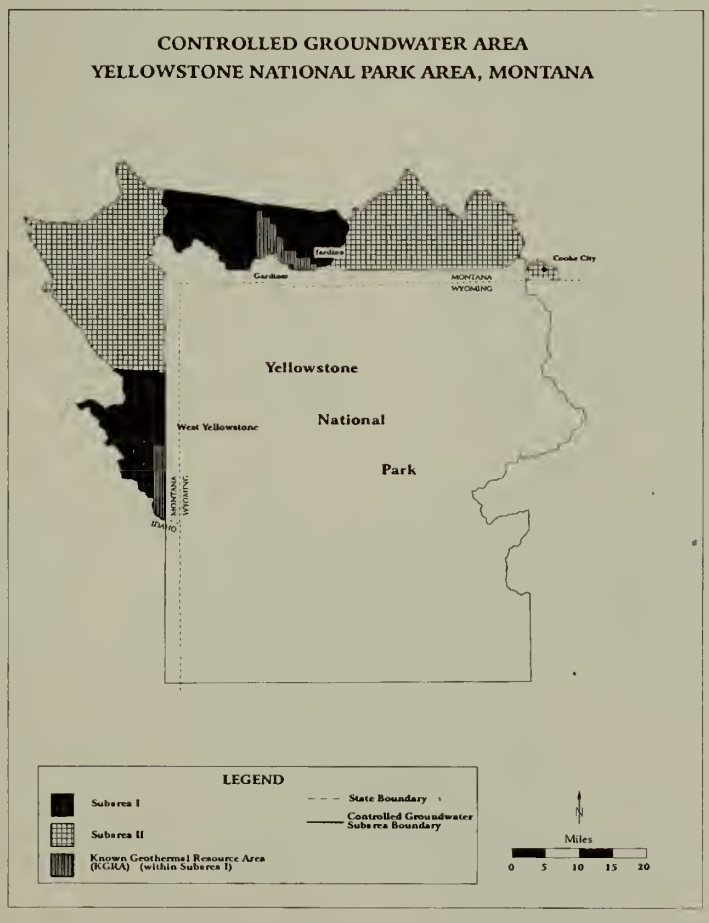
Unfortunately, in Yellowstone this larger hydrothermal system is not entirely encompassed within park boundaries. Studies of areas with hydrothermal features to the north and west of the park indicate that there are trans-boundary connections between surface and/or subsurface hydrothermal features.

Protection and management of the park's hydrothermal resources requires the park to consider the consequences of any activity that could alter the pressure, temperature, or water flow path characteristics of Yellowstone's hydrothermal system. Recently, private development activity in Montana just north of Yellowstone has highlighted concern about protection of the hydrothermal system.

The federal reserve water rights negotiation process gave the Na-

tional Park Service an opportunity to apply the usual rules of western water law to protecting Yellowstone's hydrothermal system. The compact with Montana includes provisions for (1) adjudication of the United States' right to maintain water in the hydrothermal system within the boundaries of the park, (2) a requirement that a permit must be obtained prior to development, (3) a limitation of water use by permit conditions, and (4) the guarantee that the state will administer conflicts between the United States' right and other water uses within a "controlled groundwater area" outside, but adjacent to, the park.

The National Park Service also recognized that there are areas where traditional western water law may fail to protect Yellowstone's hydrothermal system and it's unique characteristics. For example, even with advance notice of development plans, the scientific evidence necessary to definitively predict impacts is not always available. Although scientists researching Yellowstone's hydrothermal system have gained some insight into its extent and function, they have not yet definitively described the system, nor do they have the technical tools necessary to predict impacts from various development scenarios. In addition, even the application of the best available technical analysis may result in inconclusive findings subject to several equally legitimate interpretations. The complexity and sensitivity of the park's hydrothermal system may never be fully understood. Often complete understanding of such a system comes only if it can be dismantled.



All groundwater development within the delineated Yellowstone Controlled Groundwater Area shown on the adjacent map will require a permit. The boundaries of the area were based on recommendations made by a group of scientists from the Montana University who were familiar with the specific geologic, geophysical, geochemical, and hydrologic conditions of the area.

Where uncertainty exists, typical western water law would probably have the development proceed, possibly with monitoring. The burden then would fall on the National Park Service to demonstrate impairment, which, as described above, would be difficult if not impossible. By negotiating, as opposed to litigating, both parties were able to address this concern by agreeing that any scientific doubt concerning adverse effects will be resolved in favor of protection of the hydrothermal system within Yellowstone. Approval of any development permit requires a review of the permit by scientists with hydrothermal system expertise. Clear and convincing evidence will be required that no potential exists for adverse effects to the hydrothermal system. A technical oversight committee was established to provide the scientific review and guide technical data-gathering efforts within the delineated area. (See map.)

While the compact is a milestone in the protection of the park's resources, it does not cover all exigencies. Certain types of deep drilling could introduce new water/steam flow paths, thus changing the pressure in the system. Additionally, other types of thermal resource development, such as heat exchange units, could remove heat from the system. Such activities may not be subject to the legal requirements of the water rights compact. To cover these areas as well as include areas surrounding the park in Idaho and Wyoming, Representative Pat Williams (D-Montana) has introduced the "Old Faithful Protection Act." This act would temporarily prohibit any development that could affect Yellowstone's thermal system until the states develop a program for protecting the system.

NEWS BRIEFS

Park Service I&M Program Initiates Vegetation Mapping

As one component of the Servicewide Natural Resource Inventory and Monitoring Program, the National Park Service has initiated a major effort to map the vegetation of the majority of park lands under its jurisdiction. The areas to be mapped include all natural resource park units and environs in the United States and possessions, excluding Alaska. The purpose of the mapping initiative is to provide uniform, consistent baseline data that documents the state of vegetation in national park areas in the mid-1990s time frame.

The agency's recently developed Natural Resource Inventory and Monitoring Guideline (NPS-75) emphasizes the need to collect quality inventory and monitoring data on a long-term basis. The vegetation mapping initiative is a significant step in that direction. Besides generating baseline data for long-term inventory and monitoring goals, the vegetation maps produced through this effort will also have shorter-term applications for park research, resource management, planning, interpretation, and operations. Examples of applications include habitat analyses, fire fuel modeling, site suitability analyses, evaluation of resources at risk, ranger activities, general management plans, resource management plans, etc.

Many parks and some National Park System regions have undertaken vegetation mapping in the past, using a variety of techniques and methodologies that focused on specific purposes for those data. Although this met the immediate needs of the parks, the data generally have not been consistent from one area to another.

The vegetation mapping project is being carried out by the Park Service through a partnership with the National Biological Service, who will provide funding and technical oversight for the project. In 1993, the National Park Service awarded a five-year contract to Environmental Systems Research Institute, Inc. This company enlisted a team of professional sub-contractors, each recognized leaders in their respective areas of expertise, to complete the project. Those sub-contractors include The Nature Conservancy, the National Center for Geographic Information and Analysis, Merrick & Company, Aerial Information Systems, and EA Engineering Sciences and Technology.

Mapping vegetation Servicewide will take several years to complete. Expected early accomplishments are: (1) establishment of national vegetation classification standards, (2) development of standard methodology and protocols for consistent data gathering and management, (3) development of standard methodology and protocols for accuracy assessment, (4) protocol testing and evaluations in four "pilot" units, (5) assessments of existing data sets in the first 100 units on the Servicewide priority listing, (6) aerial photography acquisition for approximately 75-80 units, and (7) completed mapping projects for approximately 10 prairie park units.

Agencies Conserve Native Plants

In 1994, eight federal agencies joined together with 40 non-government organizations to form the Federal Native Plant Conservation Initiative. This cooperative venture is designed to coordinate native plant conservation efforts. Member agencies will pool information and expertise and work together to educate the public, promote conservation activities, and conduct research.

Federal agencies manage up to 29% of the nation's lands and provide habitat for innumerable native plant species. According to the Center for Plant Conservation, more than 200 species of native plants have gone extinct since the early 1800s, and nearly 5,000 species of native plants are "at risk" in the United States. Yet only 525 of these native plants are protected by the Endangered Species Act. Plant protection and recovery activities are generally underfunded and fewer than half of the endangered plants have approved recovery plans.

The Federal Native Plant Initiative will attempt to bring the plight of native plant to the eyes of federal land managers and the public. Already the group has recieved a grant from the National Fish and Wildlife Foundation, which, with matching funds, will provide $250,000 for native plant conservation work. Signatories to the Memorandum of Understanding include the Fish and Wildlife Service, National Park Service, Bureau of land Management, National Biological Service, Agricultural Research Service, U.S. Forest Service, Natural Resources Conservation Service, and Department of Defense.

NEWS BRIEFS

Wilderness Conference Yields Concrete Recommendations

Eight hundred participants in the annual Wilderness Conference drafted and presented recommendations for advancing wilderness stewardship to top Department of the Interior officials. Department and agency leaders responded with a promise to invigorate protection and management of the National Wilderness System.

Held in Santa Fe, New Mexico, on November 14-18, 1994, this sixth wilderness conference tapped the expertise of conference participants to produce a strategic plan for wilderness protection. The conference was planned and conducted by representatives from the National Park Service, National Biological Service, Fish & Wildlife Service, Forest Service, Bureau of Land Management, and Society of American Foresters Wilderness Workgroup. Participants included agency personnel, students and professors from eight universities, and numerous outdoor retailers and conservation groups.

Speaking to conference attendees, Park Service Director Roger Kennedy highlighted the new Servicewide wilderness initiative. "We must reengineer and restructure to provide the needed consistency and support, because national park wilderness is the highest degree of protection and stewardship we can offer." The Director's Task Force Report--signed 30 years to the day of President Johnson's signing of the Wilderness Act--espouses a National Wilderness Program Leader, sets ambitious wilderness hiring and training goals, and calls for a National Wilderness Steering Committee to be chaired by the Deputy Director. The report may be obtained from Wes Henry, Division of Ranger Activities, Washington, D.C.

The Wilderness Conference Handbook, compiled by Charisse Sydoriak (Bandelier), may be obtained from Society of American Foresters, 5400 Grosvenor Lane, Bethesda, Maryland, 20814.

Gray Wolves Released Into Yellowstone

In March 1995, 14 gray wolves were released into Yellowstone National Park. This release marks the beginning of a long-term effort to restore gray wolves into the Yellowstone ecosystem. For the next three to five years, wolf releases will continue, with recovery projected for 2002. The wolves were transplanted from Canada, where they are not endangered.

Originally an integral part of the Yellowstone ecosystem, wolves were exterminated by the turn of the century. Reintroduction of the wolves into Yellowstone will reestablish more complete predator/prey relationships and add to the long-term stability of the natural biological and evolutionary processes in the Yellowstone biome.

The Yellowstone wolves have been designated as experimental populations, allowing greater management flexibility when dealing with animals preying on livestock. Following strict regulations, a wolf can be killed if it begins to prey on livestock. The complete details of the rules were published in the November 22, 1994, Federal Register.

NEWS BRIEFS

Task Force Evaluates Exotic Weed Management in the NPS

Kudzu, purple loosestrife, leafy spurge, and salt cedar (tamarisk) are among the dozens of exotic plants that are invading national parks and replacing native vegetation. Several parks in Florida, Hawaii, and elsewhere have aggressive projects for controlling exotics. However, most parks do not have the resources to launch thorough, and expensive and time-consuming, exotic weed management programs. Without a largescale management program across the nation, the National Park Service may win an occasional battle against invasive weeds, but lose the war.

To address the problem of exotic weed management, National Park Service Director Roger Kennedy established a Temporary Task Force on Invasive Non-Indigenous Plant Management. The task force will evaluate the National Park Service's current management efforts and develop recommendations for the Director. The Task Force is looking at operational activities, budgets, staffing, technical assistance, training, public outreach, and similar functions. The final report is scheduled for completion by late fall.

Kudzu (Robert Sutter, TNC)

The Task Force members are: Mack Shaver, Channel Islands, Chairperson; William Wade, Shenandoah; Terry Cacek, Wildlife and Vegetation Division; Bob Doren, Everglades; Terri Thomas, Golden Gate; Ron Hiebert, Midwest Regional Office; Cindy Nielson, Glacier; Lloyd Loope, National Biological Service, Hawaii; and Rocky Beavers, Denver Service Center.

Park Service staffs are working concurrently with external weed management organizations. The Park Service is a member of the newly formed Federal Interdepartmental Committee on the Management of Noxious and Exotic Weeds, which will coordinate weed management activities among various land management, research, regulatory, and education agencies. Parks in at least four regions have helped establish Exotic Pest Plant Councils to coordinate weed management in their geographic areas.

Marine Debris Monitoring Program Completed

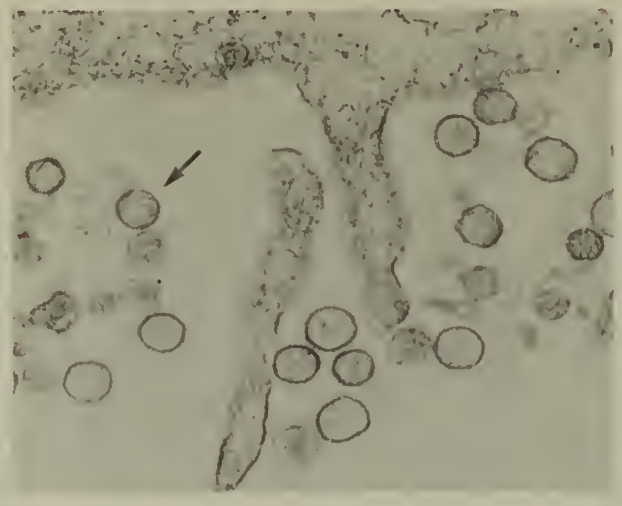
From 1989 to 1993, the National Park Service, the National Marine Fisheries Service, and the Environmental Protection Agency cooperated in a five-year study to quantitatively assess the abundance, composition, and accumulation of marine debris on national park system beaches on the Atlantic, Gulf of Mexico, and Pacific coasts, and the U.S. Virgin Islands. The five-year program was the first large-scale effort made in the United States to identify and categorize marine debris.

Ten park units participated in the study: Olympic National Park, Channel Islands National Park, Padre Island National Seashore, Gulf Islands National Seashore, Dry Tortugas National Park, Virgin Islands National Park, Canaveral National Seashore, Cape Hatteras National Seashore, Assateague Island National Seashore, and Cape Cod National Seashore. Major accomplishments include: identification of indicator items which can serve as indices to the entire debris load; determination of survey frequency for future studies; ability to ascertain the effectiveness and accuracy of volunteer participation; heightened public awareness of marine debris issues in parks participating in the program; and interagency cooperation and mobilization on an important national issue. The final report of the Marine Debris Monitoring Program will be available this summer.

Hantavirus Checked by IPM Techniques

By Carol DiSalvo, Servicewide IPM Coordinator, Wildlife and Vegetation Division

Without warning, hantavirus appeared in the Southwest during the spring of 1993. Flu-like symptoms including muscle aches, headache, fever, and cough rapidly progressed to severe respiratory distress and, sometimes, to death. According to the Centers for Disease Control (CDC), 39 deaths from the 78 confirmed cases of hantavirus occurred in 1993 and 1994. Because the disease is spread by symptomless rodents, Park Service field employees became seriously concerned.



Hantavirus

The CDC immediately began an intensive investigation on the etiology of the disease and initiated a nationwide survey. The CDC requested cooperation from the Park Service to determine the prevalence of the disease. Field personnel provided assistance to five CDC survey teams established across the country. Rodents from 38 parks were sampled and tested for presence of hantavirus antibody. Preliminary analysis shows presence of hantavirus antibodies nationwide.

The virus and its rodent reservoirs were first discovered in 1993. The hantavirus, family Bunyaviridae, consists of a single strand of RNA that is capable of swapping RNA, enabling the virus to produce new genetic types, each specific to a different rodent species. Infected rodents never actually contract the disease, but act as carriers or vectors. Infected rodents shed the virus in saliva, urine, and feces for many months. Experts do not yet know how long the virus remains viable on dead rodent carcasses. Human infection occurs when infective saliva or excreta are inhaled as dried airborne particles.

Experts believe that the hantavirus has been in the United States for several decades. Hundreds of deaths due to unknown causes are recorded annually under the unexplained "adult respiratory syndrome," or ARDS, category. Many samples from unexplained deaths of the past labeled ARDS have been tested and attributed to hantavirus.

Why did the four corners area of New Mexico have so many concurrent hantavirus cases? It is thought the high bumper crop of pinyon nuts, seeds, and berries caused mice populations to boom. Six thousand mice per square mile were recorded in New Mexico during the summer of 1992. Overcrowding and competition cause disease-spreading behavior, such as biting and marking territory with urine. In addition, spreading human development in this area leaves less natural habitat for native rodents and other animals, hence more mice-human interaction. Mice and rats adapt well to human habitation. As natural areas become developed, rodents will continue to adapt and coexist in human habitation.

To address the hantavirus problem, the National Park Service suggested to the CDC an integrated pest management (IPM) approach, rather than a conventional baiting (rodenticide) program. Breaking away from a historical use of rodenticides, the CDC agreed to support the Park Service's use of IPM methods and, further, to conduct studies to test the methods' efficiency. This approach involves removal of food sources, mechanical exclusion of rodents, and use of snap traps for those that still get in. Working with Johns Hopkins University, the CDC is conducting and funding a study of rodent-proofing in four parks to determine if, in fact, mechanical rodent-proofing measures statistically decrease the incidence of rodent access and human-rodent interaction. CDC-hired IPM Specialist Jerry Hoddenbach is overseeing the study. At this date preliminary results from the study currently underway at Sequoia-Kings Canyon, Grand Canyon, Shenandoah, and Yosemite indicate the effectiveness of rodent-proofing. Structures that have been "rodent-proofed" are reporting fewer rodents. As Jerry Hoddenbach puts it, "if you keep them out, they can't get in."

Treatment for hantavirus is now available. However, other risks, such as Lyme disease or dengue, still exist in the field. Management of risks associated with all naturally-occurring animals will require well-thought-out management strategies and the continued cooperation of dedicated employees.

Stewardship Today for Parks Tomorrow

By Larry Bancroft, Chief of Science and Natural Resources Management, Jay Goldsmith, Natural Resources Specialist, Western Regional Office, Abigail Miller, Program Coordinator, Natural Resources, and Ronald Hiebert, Chief Scientist, Midwest Regional Office

Through its "Stewardship Today for Parks Tomorrow" Initiative, the National Park Service has made a commitment to improve our ability to preserve and protect the natural resources of the parks. This long-term program will build the field capability--whether in resource management, maintenance, resource protection, or natural resource interpretation--needed to manage park natural resources in a scientifically sound manner. It will include natural and cultural resource management and protection needs.

This program builds on recent professionalization efforts included in the Natural Resource Professional Development Program and uses the recently completed Natural Resources Management Assessment Program (NR-MAP) to objectively assess the base staffing and funding needed to implement thorough natural resource management programs in all National Park Service units. The NR-MAP results indicate that servicewide, natural resource management programs are currently funded at about 25%. The goal of the initiative is to initially bring natural resource management staffing to approximately 50% of what NR-MAP has shown is needed--a doubling of park personnel involved in natural resource management.

Information to identify the total natural resource management and research needs in a park is obtained through a five-part process.

Step 1. Parks fill out a Park Profile questionnaire providing specific, objective information about the natural resources of the park and visitor use activity in the park. This information is indicative of the workload associated with the various natural resource and research program areas (e.g., vegetation management and wildlife management). The program and sub-program areas are based on natural resource management program areas identified in the *Natural Resources Management Guideline*, NPS-77. The four basic elements of natural resource management (knowing, restoring, maintaining, and protecting) are addressed in each program area. Developing interpretation information on natural resource issues is also included.

This long-term program will build the field capability needed to manage park natural resources in a scientifically sound manner.

Step 2. Information from the Park Profile is applied to allocation tables that identify the workload--measured by FTEs--resulting from the resource needs. The tables also identify the types of professional and technical positions that would perform work for the program identified.

Step 3. Park support and infrastructure needs are identified. This includes clerical, administrative, and maintenance support; office space needs; and program support costs (e.g., vehicle costs, travel costs, and project support funds).

Step 4. A budget strategy is formulated to begin closing the gap between current staffing levels and the fully-funded programs identified by NR-MAP, including setting needs priorities. A staged implementation plan enables parks to effectively absorb these staff increases.

Step 5. A position management process is applied to translate these staffing needs into organizational charts for parks, area offices, cooperative park study units (CPSU), and regional offices, also on a priority basis. Organizational charts will be prepared reflecting both full funding and funding at the phase I level identified in step four.

The completed assessment has been applied to 269 parks with significant natural resources. Profiles of park natural resources (e.g., miles of streams, number of species managed, and number of species harvested) and management environments (e.g., park configuration and size, remoteness, and number of neighbors) have been used to determine staff needed in each area (e.g., exotic plant management, water resource management, and cave management) to conduct a comprehensive natural resource management program. The computerized allocation tables used to obtain program workloads have been subjected to a number of statistical analyses. The NR-MAP data suggest that currently, servicewide we are only at about 23% of the needed staffing level in natural resources.

Originally initiated in the Western Region to meet the needs of

superintendents, the development of NR-MAP has truly been a broad-based, grassroots effort. Sixty-seven parks, two area offices, four CPSUs, and a total of over 900 individuals participated in the development and implementation of NR-MAP over a four-year period.

The Western Region's Natural Resources Management and Science Task Force, composed mostly of superintendents, concluded that "more information is needed about park requirements in order to meet natural resources management responsibilities. The Regional Office should facilitate an analysis of what the parks need to monitor natural resources and address natural resources issues. This analysis should address the types of positions necessary to implement a thorough natural resources management program in Western Region parks. This inventory should be consolidated into a clear, concise, prioritized regional overview. To meet these basic needs the Region should develop a coherent and comprehensive funding request." A seven-person working group, composed of a park and regional natural resource manager a regional computer specialist, park scientist, park and Washington Office program analyst, and position management/staffing specialist, was formed to address this.

Following completion of the NR-MAP project for the Western Region, the Associate Director, Natural Resources, sponsored testing and expansion of NR-MAP to address parks nationally. Subsequently, workshops were held with natural resource managers from each of the other nine National Park Service regions. These workshops yielded modifications to the original NR-MAP prototype that address all of the major natural resource programs in parks throughout the Service. A total of 17 major natural resource programs and 72 subprograms are now identified in NR-MAP.

The NR-MAP process resulting from this extensive effort is similar to the FIREPRO process. The base staffing and funding needs of a park are objectively identified based on the complexity and extent of the park's natural resources. This approach allows consistencies in program levels and staffing between parks of similar size and complexity. NR-MAP does not identify large short-term project needs. Such projects will continue to be met by servicewide or regional project funding sources.

New *Park Science* Editor Committed to Research/Resource Management Connection

By Jeffrey M. Selleck, Editor, Natural Resources Publication Office

After 14 years, *Park Science* has a new editor. Jean Matthews, the founder and only editor of the natural resources management bulletin, retired in October 1994. The new editor, Jeff Selleck, worked closely with Jean for six months to learn the ropes before taking over his editorial responsibilities. Jeff comes to *Park Science* from Big Bend National Park, Texas, where he worked as an interpretive supervisory park ranger, with an emphasis on publications.

As a result of this changing of the guard, the editorial board of *Park Science* met to examine the role of the quarterly publication in the future. Unanimously, the board emphasized the importance of maintaining the bulletin as a forum for relating field research to resource management. Resource professionals and scientists consider *Park Science* an important information source, partly due to its strong connection to the field.

To keep this connection strong, Jeff plans to continue soliciting articles from the field. To keep information current, Jeff will look for ways to relate information from the field to current resource management trends. For example, as the National Park Service takes steps toward managing ecologically similar parks in similar ways, *Park Science* will publish landscape ecology or ecosystem research articles that have broad applicability across the National Park System. At some point, an ecosystems highlights department may replace the current regional highlights section of the publication. As cooperators such as the National Biological Service, U.S. Geological Survey, and others conduct research on park lands, researchers and resource managers from the different agencies will be asked to coauthor articles to encourage these growing partnerships and share important information. *Park Science* will also publish park-developed solutions to global natural resource problems.

With attention to the basics of publishing useful research and resource management information, *Park Science* is poised to continue to serve its readers and influence the direction of research and resource management for years to come.

Stepping Into Resource Management

Step 1

KNOW
what resources
are managed and
their condition

California's Threatened Island Fox Gets Help From Government and Private Organizations

By Catherin Schwemm, Wildlife Biologist, Channel Islands National Park

Around 30,000 years ago, a gray fox may have clung to a piece of wood during a storm, floating from the Southern California coast out to an island. Maybe this fox was pregnant and gave birth, or maybe it was joined by other foxes. Either way, these animals ultimately colonized an area that would eventually become the California Channel Islands.

As the seas rose and the land split into individual islands, Native Americans carried the foxes as pets from one island to the next. Two of the smallest islands could not support fox populations, but the six larger islands provided good habitat. Over time these mid-sized canids evolved to be about half the weight and one-third the size of the original traveler. Because of these differences, the island fox has earned a species designation of its own. Due to restricted distribution and limited genetic diversity, the island fox is now a threatened species in California.

In 1993, Channel Islands National Park began long-term monitoring of the island fox to provide information to be used to conserve this species. However, three other entities have jurisdiction for lands containing island fox habitat: the U.S. Navy, The Catalina Island Conservancy, and The Nature Conservancy. Channel Islands staff decided early on that an island fox monitoring program would be useful only if our methodologies were comparable and/or complementary with those on the other islands.

At the beginning of our program park staff talked with all known living scientists who had participated in island fox research. At the same time, the park signed on as a partner in a cost-share proposal to help fund a UCLA Ph.D. student working on island fox genetics on Santa Cruz Island, which is owned by The Nature Conservancy. Luckily, several of the researchers interviewed had many years of experience in live-trapping island foxes, which was the technique the park planned to use for mark-recapture studies. These folks generously shared humane and functional techniques that they had developed after much trial and error.

Island foxes are about one-third the size of their gray fox ancestors. They live only on six of the California Channel Islands. Their limited distribution and genetic diversity has earned them threatened status in California.

At present, seasonal mark/recapture studies to estimate density, recruitment, and distribution are conducted on four of the six islands where island foxes live. The Park Service uses passive integrated transponders (PIT), permanent markers injected under the skin of the animal, which eliminates the need for external markers. The Navy researchers, contractors working for the Navy, and The Natural Conservancy all plan to use PIT when funding becomes available.

Channel Island's research has also increased the knowledge of the life history of the island fox by documenting the life expectancy of these animals. The surprising recapture of foxes trapped and marked for study during the 1980s proved that these animals commonly live up to eight or nine years, a fact never documented before. This information has helped researchers on other islands to make accurate age distributions and estimations.

While island fox populations currently seem to be healthy, several threats exist. The most immediate concern involves the possibility of the introduction of canine diseases to the islands. None of the island fox populations are known to have been exposed to such common mainland diseases as rabies and distemper. If either of these viruses were to be brought to the islands, it is possible that an entire population of island foxes could be at risk. While dogs are not allowed on the Park Service islands and are strictly regulated on the others, private boaters and other visitors still bring dogs to the islands. Significant reductions in population estimates found during routine monitoring could provide an early warning of any fatal disease within the system.

Another threat to the island fox is the loss of habitat as a result of non-native animal disturbance on both public and private lands. Wild pigs, house cats, cattle, sheep, deer, and elk all live on islands with island foxes, and almost certainly compete with them for food, habitat, and other resources. The island fox evolved as the largest carnivore on the islands and may not be capable of existing with these introduced species indefinitely. Low population numbers on several of the islands make the fox populations on those islands vulnerable to random changes in their environment. And finally, all wildlife on the islands would be at great risk in the case of an oil spill. Many oil tankers travel within miles of the islands, and many people feel that the question is not if an oil spill will occur, but when.

All of the islands with island fox populations face these threats. By working cooperatively, the Park Service and the other entities responsible for the island foxes' conservation are increasing the knowledge of the biology and ecology of this special animal, and thereby the ability to protect this unique species.

Americorp Helps Dry Tortugas Survey Sea Turtles

By Carolyn Wiley, Chief Ranger, Dry Tortugas National Park

In 1513, Ponce de Leon visited a group of six waterless keys seventy miles west of what is now Key West, Florida. He found an abundance of sea turtles and called the islands Las Tortugas, or "the turtles." Mariners added the word "dry" to signify the lack of fresh water. Half a century later, Dry Tortugas National Park still supports a significant number of sea turtles.

Thanks to Americorp Project funding in 1994, Dry Tortugas was able to document sea turtle nesting activity from the beginning of the season until the hatch was complete. Coordinated by Everglades National Park employee Jim Brown and Americorp Project enrollee Christopher Scott Boykin, workers documented seventy-two nests of various sea turtle species.

Loggerhead Key and East Key contained over 95% of the turtle nests found during this survey. Both these keys were marked with numbered PVC pipes at 100' increments. When a sea turtle crawl was found, distance and direction were recorded in reference to the closest marker. A numbered stake was placed adjacent to the body pit. Excavation of the nest took place three days after emergence of the hatchlings. If emergence didn't occur, excavation took place 70 days after the crawl was documented. Hatchlings found in excavation were released on site. All egg shells were counted and unhatched eggs were opened to determine infertile and undeveloped eggs. Green hatchlings were easily identified, but the inframarginal scutes were closely observed on loggerheads in the event we should have a hawksbill nest.

This year was a record year for green turtle nests in Dry Tortugas National Park, with twenty-five known nests. Positive identification was verified either by traplings or undeveloped embryos. Unknown green turtle crawls were distinguished by their large, deep body pits that were usually in the vicinity of vegetation lines. When unhatched eggs were undiscernible and no traplings were present, the remainder of the nests were deemed loggerheads. Mature hawksbill turtles have not been recorded. However, juveniles were frequently seen on the reefs of the Dry Tortugas.

Yellowstone Research Focuses on Microbial Resources

By Bob Lindstrom, Management Assistant, Yellowstone Center for Resources, Yellowstone National Park

In Yellowstone National Park, a unique microbial community of high-temperature (thermophilic) bacteria thrives in the 10,000 hot springs and geysers of the Yellowstone Plateau. Thermophilic bacteria inhabit rare microniches believed to resemble the Earth's earliest biosphere, four billion years ago. Currently, 40 research projects in Yellowstone are studying these organisms and how they interact with the biogeochemical cycles of the earth. Products of microbial research, including high-temperature enzymes from thermophiles, have changed the face of modern biological science.

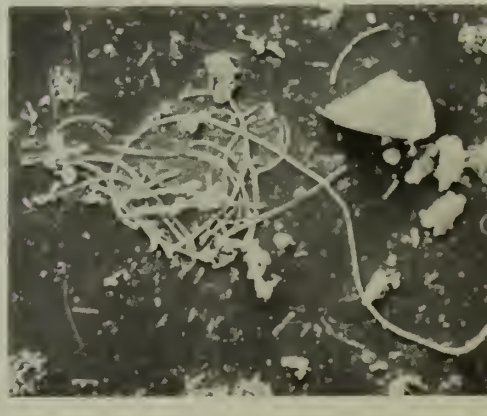
Thermophilic bacteria produce high-temperature enzymes. These naturally occurring protein catalysts are the fundamental tools of biological engineering. One such enzyme from the organism *Thermus aquaticus* (*Taq*) led to a revolution in biotechnology with the Nobel Prize-winning process called PCR (polymerase chain reaction). The patented process has been worth billions of dollars to the biotechnology industry and provides medical and forensic science with a powerful diagnostic tool for detection of minute quantities of DNA, including the only reliable test for HIV.

The genetic components of thermophilic microorganisms, which produce these valuable enzymes, are a brand new national treasure. *Taq*, along with several other original Yellowstone research specimens, have been granted U.S. patent protection for such industrial uses as the production of fermentation products, including gasohol, and genetic engineering tools such as restriction endonucleases, which cut and glue segments of DNA, permanently creating new life forms. Bioremediation of environmental pollution such as oil spills, acid mine waste, and nuclear contamination are among other focuses of current thermophile research.

Microbial research in Yellowstone also may lead scientists to answers about life on Mars. On the rim of Angel Terrace, site of a NASA research project studying the role life plays in the formation (biogenesis) of the massive Mammoth Terraces, Yellowstone is being used as a model in NASA's search for extraterrestrial life. Because the planet Mars had an ocean during the time life evolved on Earth, NASA scientists believe life evolved on Mars as well. Primitive bacteria, like those in Yellowstone, which need neither sunlight nor oxygen to flourish, could remain in the active volcanoes and hot springs on Mars. If high-resolution satellite imagery can show hot spring terraces on the Martian surface, the presence of life can be extrapolated. Because terraces are similar to coral reef for-

Scientists from Regensberg, Germany, prospect for new microbes in Yellowstone's hot springs.

Biodiversity prospecting in Yellowstone hot springs yields the oldest life form yet discovered, Archaebacteria .



mations, fossils of organisms entombed in rock may provide physical evidence of extinct species.

In 1994, the Yellowstone Center for Resources initiated the Thermophilic Microorganism Survey, a baseline inventory of this enigmatic resource. The Survey currently includes more than 30 published organisms and serves as a database repository for new species being discovered at an increasing rate by new techniques made possible by PCR. One new discovery (pJP-78), found in an iron hot spring in Yellowstone's central Hayden Valley, is the oldest life form yet discovered, the closest known relative to the origin of life on Earth. Because more than 90% of this rare ecosystems inhabitants remain unknown, future discoveries may lead to even more profound enterprises.

GIS Provides Detailed Soils Map for Glacier National Park Quickly and Inexpensively

By Richard Menicke, Geographer (GIS), Glacier National Park

After nearly a year's work, Glacier National Park will have a comprehensive map of the soils in the park. This map will show soil delineations to 5-acre minimum map units, describing soil depth, horizonation, texture, rock content, color, water-holding capacity, and parent material. The accuracy of the soil delineations is expected to be greater than Soil Conservation Service Order III soil survey results. The time and cost involved will be a fraction of that associated with conventional field mapping techniques employed by the Soil Conservation Service.

Reliable soils information is an important component of resource planning and management decision-making on public lands. Knowledge regarding a variety of ecosystem processes, and resulting park management concerns, relies in large part on the understanding of the distribution of soil types across the landscape. Before the development of the parkwide soils map, soils information in Glacier was gathered on a project basis across a limited geographic area.

Soil distribution is linked to physical and biological parameters that influence soil formation over time. Many of these physical or environmental conditions are identifiable using a geographic information system (GIS). The availability of GIS thematic data describing topography, surficial geology, and vegetation allows such.

Predicting a soil type's occurrence across the landscape is possible when "expert system" computer software is used to query the GIS database. Expert system software is often a set of criteria or decision-making rules based on known relationships that translate human knowledge of a particular subject into computer code. This form of software has existed for many years, originally intended for military application, and can be developed on an application-by-application basis. Results are generated within a GIS when the expert-defined rules set is used to query the GIS database. Those areas meeting the defined criteria are calculated and displayed. For example, locations for the Ovando soil series could be predicted by querying the GIS to display those areas meeting the following criteria: granite parent material, north facing slopes above 4500' or south facing slopes above 6000', 8-60% slope, medium canopy coverage, and straight to convex profile curvature.

The marriage of GIS and expert systems provides an appropriate technique for cost-effective soil mapping across large areas. Paramount to the success of this methodology is the availability of a soil scientist familiar with regional soils and the environmental conditions under which they occur. Preliminary inferences are made based on the soil expert's existing body of knowledge. Field surveys are then conducted to evaluate these initial predictions and new information concerning soil/environment relationships is gained in the process. Through this type of iterative approach, the definition of the soil/environment relationships improves until a satisfactory level of soil description is achieved.

The inference of soil distribution in the McDonald drainage (110,000 acres) of Glacier National Park began in July 1994. After approximately one month of intensive programming, computing, and field survey work, a draft soils map was completed for the entire drainage. Subsequent field survey in August through early November provided adequate information to further define soil/environment relationships throughout the basin. A final soils map of the McDonald drainage is expected in March of 1995.

While the McDonald drainage soils mapping was considered a pilot study area for testing the expert system approach, this technique may be applied to other major drainages in Glacier Park where soils information is lacking.

Breeding Birds Counted at Indiana Dunes

By Eddie L. Childers, GIS Specialist, Indiana Dunes National Lakeshore and Ralph Grundel, Research Ecologist, Lake Michigan Ecological Station, National Biological Service

Taking advantage of important breeding and migratory bird habitat remnants remaining at the southern tip of the Lake Michigan basin, the staffs of the Indiana Dunes National Lakeshore and the Lake Michigan Ecological Station have jointly initiated a comprehensive series of breeding bird surveys. In June 1993, the combined staffs began a long-term program to monitor breeding birds at the national lakeshore. The objectives of the surveys are to:

1. complete annual surveys to determine long-term trends in species diversity and changes in relative abundance of avian species at the national lakeshore,

2. describe breeding bird habitats at the national lakeshore, and

3. provide information for the national breeding bird survey.

Indiana Dunes Resource Management Division staff will use the survey data to monitor and manage neotropical migratory birds throughout the national lakeshore. National breeding bird survey data from 1982 to 1991 suggest that a significant decline of many neotropical migratory bird species has occurred in the Midwest. One possible cause for this decline is habitat fragmentation, a landscape level change that has greatly affected the southern Lake Michigan basin and the national lakeshore in the past. Presently, restoration of many areas of disturbed and fragmented habitat in the national lakeshore is underway by the Resource Management Division.

Even though the national lakeshore's landscape is highly fragmented and disturbed, Indiana Dunes still represents the last large "island" of protected breeding bird habitat remaining in northwest Indiana. Furthermore, national parks serve as "control sites" for long-term monitoring of breeding avifauna. The national lakeshore avian surveys will, therefore, contribute valuable information on the status and trends of breeding birds in the Lake Michigan basin.

The lakeshore's 12,000-plus acres offer birds a diversity of habitat types. The lakeshore contains four major stages of Lake Michigan vegetative succession. The active beach zone exhibits all stages of vegetative succession, including open beach, grass-covered dune ridges, blowouts, dunes with woody shrub vegetation, pine-forested dunes, and oak-forested dunes. A stable oak forest characterizes upland dune areas. Wetland areas in the national lakeshore, historically more prominent than today, include ponds, marshes, swamps, peatlands, bogs, and fens. Over 1,400 different plant species have been catalogued at the national lakeshore. In addition to biological riches, Indiana Dunes' strategic location on the southern tip of Lake Michigan makes it an important stopover for many migratory species of breeding birds and waterfowl.

Breeding bird surveys are conducted in the national lakeshore's main East and West units as well as in several smaller areas of special interest. The surveys include all of the park's major habitats. After only two years of surveying, several unique observations have already occurred in the East Unit of the national lakeshore. In 1993 and 1994 we observed the Chuck-will's widow breeding several hundred miles further north than previously known in the state of Indiana. Also noted in the East Unit during the 1993 survey were the Canada warbler, chestnut-sided warbler, black-throated green warbler, magnolia warbler golden-winged warbler, veery, and ovenbird, all species rare for the area or in a state of decline.

Two unique habitats, Pinhook Bog and the Heron Rookery, received special consideration in the development of the breeding bird surveys. Pinhook Bog, a floating peat-mat community formed over the surface of a former glacial lake, represents the only true peat bog remaining at the national lakeshore. Pinhook Bog vegetation is characterized by high shrub-tamarack dominated by highbush blueberries and purple chokeberry, combined with small openings of low shrub thickets containing huckleberry and leatherleaf. Pinhook Bog habitat provides habitat for the veery, wood thrush, common yellowthroat, and American redstart.

The Heron Rookery, a 600-acre remnant of old-growth floodplain forest habitat, consists primarily of floodplain forest species such as red maple, sugar maple, American elm, red oak, white oak, and white ash. This relatively old-growth forest provides valuable habitat for the cerulean warbler, a candidate for the endangered species list, which prefer the tallest trees in the floodplain forest canopy.

The Heron Rookery also serves as an important sanctuary for other neotropical migratory and breeding birds at the national lakeshore. Located along the Little Calumet River and surrounded by cornfields, this island of woodland attracts species such as the American redstart, Acadian flycatcher, veery, great-crested flycatcher, eastern wood pewee, willow flycatcher, yellow-

throated vireo, Louisiana waterthrush, and yellow warbler.

In addition to surveys that emphasize passerine bird species, the combined National Park Service and National Biological Service effort is also censusing screech owls, barred owls, great-horned owls, Virginia rails, sora rails, great blue herons, and nightjars in separate surveys. Combined with the other censuses this information will be used by resource managers to assist in the protection of breeding bird habitat and to assess the status of the avifauna of the Indiana Dunes, the Lake Michigan basin, and the nation.

Microbes Studied in Oregon Caves Ecosystem

By John Roth, Resource Management Specialist, Oregon Caves National Monument

Microbes play crucial roles in most ecosystems, especially in caves where both biomass and the number of levels in the food chain are low. Microbes may be the first organisms in a cave to be affected by human impacts. Walking through a cave can rearrange clay particles, increase accessibility to attached nutrients, and, thus, increase microbial activity.

In 1993, the Park Service initiated what may be the first comprehensive cave inventory of any large cave in the United States at Oregon Caves National Park. The goal of the inventory was to better grasp the processes that produce 100 types of cave features and how these processes are affected by people on a public cave trail.

Each of 905 line-of-sight survey points in the cave was tagged. The area around each tag was inventoried up to halfway to all other nearby tags. This provided a complete three-dimensional inventory of all known parts of Oregon Caves. Earthwatch, a non-profit organization that links up volunteers with scientific research worldwide, provided volunteers to complete the inventory.

One of the inventory items was the macro-scale extent of "cave slime" (mostly actinomycetes bacteria) growing on walls near the cave trail. Cave slime in Oregon Caves looks like white spots of very thin lichen. Bacterial abundances and activity in cave pools, streams, and drips were studied on a microscopic level.

There was little difference in aquatic microbial activity in water near and far from the Oregon Caves trail. This probably results from the relatively high natural organic input in Oregon Caves, much of which is close to old growth forest soils. A census in a nearby cave with almost no human impacts shows similar microbial populations. Park staff sampled total organic carbon monthly for two years in various parts of Oregon Caves. This was compared to a per visitor lint production calculated from studies in Carlsbad Caverns and Jewel Cave. Unlike deeper and drier caves, such as Wind in South Dakota and Lechuguilla in New Mexico, there is not a major difference between natural and human-caused organic inputs except on the trail itself.

Humans have affected some bacteria in Oregon Caves. Cave slime was nearly absent near the public trail. A "paradox of enrichment" may ensue in which non-native bacteria adapted to a high-energy food such as clothing lint and other visitor organics outgrow and outcompete the slow-growing cave slime adapted to low-energy foods normally found in the cave.

An inventory of microbial-shaped speleothems detailed the size of the Caves' prehistoric entrances. These cave formations are coralloids shaped like popcorn and oriented toward entrances past or present. Cyanobacteria (blue-green algae) may shape them towards light by binding calcite particles through photosynthesis.

How does this research affect management at Oregon Caves? The distribution of algae-shaped speleothems has helped in determining the prehistoric size of the highly modified natural entrances to the cave. Gates have been built based on this information.

The survey point inventory showed that rounded vermiculations or "clay worms" are more common near the main trail, while the more complex forms of these clay lines on cave walls are more common further from the trail. Analysis of the rounded vermiculations show high amounts of lint and exotic cyanobacteria. The rounded clay worms will be removed as they appear to be mostly caused by lint and artificial lights.

Deposition of lint, skin, and hair in Oregon Caves doesn't appear to affect aquatic microbes as much as in some other National Park System caves. Knowing this has allowed the design of lint traps that will not affect other cave resources.

These investigations suggest that both micro- and macro-scale studies in different habitats are needed to understand microbial activity in caves. Although comparisons with similar caves are helpful, each cave needs its own census to guide actions that affect microbes.

With a three-dimensional bone and grid mapping system, paleontologists map the 33-million-year-old mammal bones at the "Pig Dig" in Badlands National Park.

Early Fossils Discovered by Badlands Visitors

By Rachel Benton, Paleontologist, Badlands National Park, and Kim Stevens, Paleontologist, Museum of Geology, South Dakota School of Mines and Technology

In 1993, two summer visitors discovered one of the more significant paleontological finds in recent years at Badlands National Park. They notified and directed the park's paleontology staff to a site containing a complex assemblage of beautifully preserved mammal bones.

Now informally called the "Pig Dig," the site contains early rhinoceroses, horses, and a very large animal which superficially resembles a wild boar. The site is unique because of the abundance of fossils and the complexity of bone arranged in a relatively limited area. Traditionally, badlands fossils are preserved in an isolated context with great distances between individual skeletons.

Badlands National Park preserves within its boundaries a great abundance and diversity of early mammalian fossils. Since the first fossil discovery in the 1840s, this area has been a center for paleontological and geological research. Even after 160 years of study, many questions remain to be answered about fossil mammals and the environments in which they lived over 30 million years ago.

The paleontology staff is presently trying to determine what mechanisms brought the jumble of bones in the "Pig Dig" together and in what types of environments the fossils were preserved. The time of preservation appears to coincide with a period of climatic transition over 30 million years ago.

To effectively answer these questions, each bone is carefully mapped in three dimensions with the use of a traditional grid system along with an electronic transit. During the 1995 field season, a detailed sedimentological analysis will be completed to further understand the environments of deposition and stratigraphy in which the bones are preserved.

Due to limited facilities and staff, Badlands National Park has developed a cooperative agreement with the South Dakota School of Mines & Technology to jointly excavate, prepare, and curate the fossils found at the site. The project is funded by a Natural Resources Preservation Program grant for a period of three years. The majority of fossil material will be collected during this time and subsequently housed at the School of Mines. At least one graduate student will be earning an advanced degree from this research project.

The site not only poses some interesting scientific challenges but also provides important management questions as well. The site location is adjacent to a moderately traveled gravel road providing easy access for researchers as well as visitors. This accessibility poses serious vandalism threats. In the summer of 1993, a boundary fence was constructed around the site and a research trailer set up to add "presence" to the site. No serious disturbances have been noted at the site.

Visitor response has been impressive during the 1993 and 1994 field seasons. On-sight interpreters answered visitor questions so that researchers could continue excavations. The site has provided a new dimension in the interpretation of fossil resources at Badlands National Park.

Step 2

MAINTAIN Resources and Systems in Their Natural Condition

Sideways Cedars Stabilize Streambanks

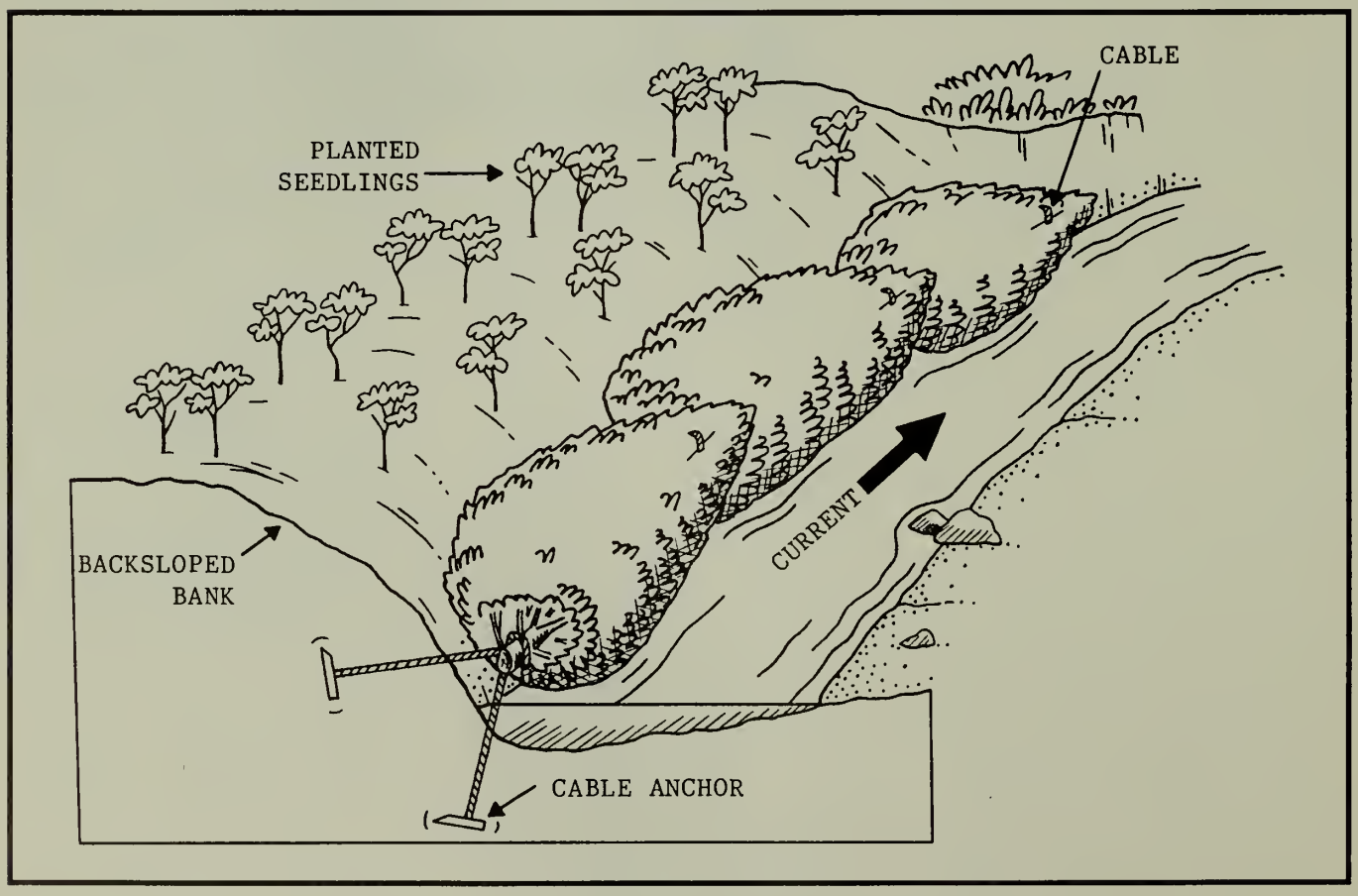
By David N. Mott, Hydrologist, and Michael Naranjo, Biological Technician, Buffalo National River

Using cedar revetments and other bioengineering techniques, Buffalo National River plans to stabilize 5,763' of eroding streambank and restore 18,881' of forested stream corridor. With funding from the Natural Resources Preservation Program, this extensive project will improve the water quality and aquatic habitats in the river and restore beauty and wildlife habitat to its banks.

The river's free-flowing status and the quality of its waters are Buffalo National River's primary concern. The National River's enabling legislation and planning documents all rank water quality and stream corridor protection as the highest priorities.

Clearing of streamside riparian forests for farming was a common practice along the Buffalo River prior to its entry into the National Park System in 1972. Many of the river's banks consist of fine alluvial sediment and become highly unstable when vegetation is removed. Even with the cessation of farming activities, many streambank erosion sites continue to experience soil loss at alarming rates (estimated as high as 40,000 tons per year at one site). As a result of this erosion, stream channels become shallower and wider, aesthetic appeal of the stream is degraded, aquatic habitats are impaired, and water quality is diminished by increased sediment loads and turbidity. The loss of forested riparian corridors also threatens the endangered gray bat, since these areas serve as important foraging habitat for the bat.

Not all eroding banks are regarded as a problem, but where streambanks and stream channels have been altered by past land use,



Schematic representation of cedar tree revetment shows anchoring method, orientation relative to current, and revegetation of back-sloped bank and riparian buffer.

restoration efforts are being considered. Resource management staff have been monitoring 25 erosion sites for 10 years. These eroding banks have been categorized according to length (250'-2300'), height (5'-32'), rate of erosion, and other factors. The average site erodes 1'-3' annually, but some sites lose as much as 20' per year. Erosion mitigation alternatives have been formulated with stream management consultants, through interagency workshops, and with representatives from the NPS Water Resources Division.

Several courses of remedial action have been attempted, including rip rap, stacked rocks, and in-channel modifications. The most successful and cost-effective method employed thus far uses natural tree revetments and restoration of the riparian forest. Tree revetments position large cedar trees horizontally at the base of the bank, anchored with cable in a continuous shingle-like fashion. (See accompanying figure.) Depending on the height of the bank, the angle of the bank may be cut back to a 45 degree slope. Seedlings of native riparian trees such as cottonwood, sycamore, oak, ash, and sweet gum are then planted on the cut bank and in a 100' riparian buffer behind the bank.

The cedar tree revetment slows the force of the flood waters and promotes deposition of sediment within the branches. The newly deposited sediment serves as a seed bed for the growth of additional vegetation, which further stabilizes the bank. Behind the revetment, the planted seedlings produce root systems that bind the soil. The cedar revetment protects the bank long enough for the trees to gain sufficient size and root mass to restore the stability of a forested streambank.

In the first year of this project, a seasonal crew of five with the assistance of a heavy equipment operator completed four revetments. Approximately 450 cedar trees and a mile of cable were used to revet banks ranging from 300' to 500' in length and from 15' to 22' high. A minimum of 40,000 seedlings will be planted during the project.

Shortly after completion of the fourth revetment, heavy rains caused the river to rise at this site almost 33' in just 36 hours. Flood waters covered the bank and most of the adjacent field. After the waters receded, concern turned to optimism—all the revetments had remained intact. Closer inspection revealed alluvial deposits within the branches.

To document the success of the restoration efforts and interpret responses in geomorphic and habitat features, a comprehensive monitoring plan has been developed and implemented. Because tree revetments have never been used to stabilize eroding banks of such magnitude, this is in many ways an experimental program.

Cooperative Efforts Help Control Exotic Plants

By Craig Hauke, Natural Resource Specialist, Canyonlands National Park

In 1991, Utah's Grand County Weed Control Specialist discovered infestations of Russian knapweed in Canyonlands National Park. Under Utah law, the National Park Service is required to manage noxious weeds such as knapweed to ensure, at the very least, that the weed does not leave the park to infest non-park lands. Working cooperatively with weed control authorities and other professionals in the field, Canyonlands now has a successful knapweed control program in place. In addition, the park has developed an early detection and control program for other exotic plant pests.

Exotic plant invasions occur often in many National Park System areas. In many cases, control of exotics seems like an insurmountable task; exotic plant populations are often well established by the time they are discovered. This seemed like the case at Canyonlands when the park was notified that the park had infestations of Russian knapweed. Russian knapweed was already well established on lands upstream from the park on both the Green and Colorado rivers. It quickly became clear that the potential existed for infestation of thousands of acres of bottom lands. Russian knapweed could easily outcompete or eliminate native vegetation in those areas.

To begin control work and comply with the State Noxious Weed Law, the park hired San Juan County Weed Control in 1991 to control nine acres of infestation along 6 miles of the Green River in the north part of the park. This was accomplished with park base funding. Assessment work was undertaken on areas that could be inventoried with existing personnel.

In 1992, the park received PRAM monies to support the project. Since the control efforts in 1991 had been 90% effective, the services of the county weed control people were again retained. They did follow up treatments and expanded the control work further south along the Green River, where an additional six acres had been discovered. Field inventories found a large infesta-

tion (40 acres) in old agricultural lands at Anderson Bottom and two small infestations along the Colorado River. Extending the inventory into Arches turned up 50 infested acres. The largest infestations in Arches were in the areas near Wolfe Ranch, where extensive grazing by domestic sheep had occurred in the past.

All but three or four acres at Arches and all known infestations at Canyonlands, except for 30 acres at Anderson Bottom, were treated in 1992. The work was done by hand using backpack sprayers and treating individual plants. All water had to be carried to the work site, as natural surface waters carried silt and minerals that would bond with the herbicide. Rodeo, a glyphosate, was used because it is specially formulated for work in riparian environments. It has proven to be satisfactory for controlling Russian knapweed.

In 1993, again with PRAM monies, all previously treated patches of Russian knapweed were retreated, and the remaining infestations were given a first treatment. With the personnel available for this project, additional infestations of exotic plants were controlled in other parts of the Southeast Utah Group (Arches and Canyonlands national parks and Natural Bridges National Monument). This included maintaining the control efforts on tamarisk at Natural Bridges National Monument and the Horseshoe Canyon Unit of Canyonlands, as well as some eradication of crested wheatgrass in the Needles District of Canyonlands.

The 1994, with reduced PRAM funds, all known areas of Russian knapweed infestation were retreated. Experience shows that control efforts work well in the year following initial treatment, but there is considerable sprouting in the second year, probably from the seed bank rather than resprouting from the roots. In most cases natural revegetation of the control sites by saltgrass has been rapid.

In 1994, the park identified another state listed noxious weed, perennial pepperweed, and treated it on three acres. As part of the 1995 exotic plant control effort, the park will retreat all Russian knapweed infestations and do an inventory of Park Service lands for perennial pepperweed. The park hopes to expand the program in the near future to treat other exotic plants that are disturbing native park vegetation, such as crested wheatgrass and tamarisk, to further ensure the integrity of native vegetation in the park and to provide for the reestablishment of native plants.

The discovery of Russian knapweed has given the park an opportunity to build a successful foundation to control and exclude other exotic plants from the park. Prior to 1991, there had been no real emphasis on exotic plant control in the park. Beginning in 1991, the park established and has since maintained effective working relationships with weed control professionals. The park now has the ability to identify exotic plant threats before they get to park lands as well as to look for those species already in the park that need to be controlled. Early detection and control is the key to identifying, controlling, and eliminating exotic plant pests.

Park and Neighbors Work Together to Manage Leafy Spurge at Theodore Roosevelt

By Roger J. Andrascik, Resources Management Specialist, Theodore Roosevelt National Park

Leafy spurge, an aggressive exotic plant, is disrupting the complex and delicate badlands ecosystem in Theodore Roosevelt National Park. Due to a lack of natural enemies, leafy spurge has rapidly expanded its range since its introduction into North Dakota by homesteading Eastern Europeans. The plant has displaced many native plants in the park and surrounding lands, including some rare species.

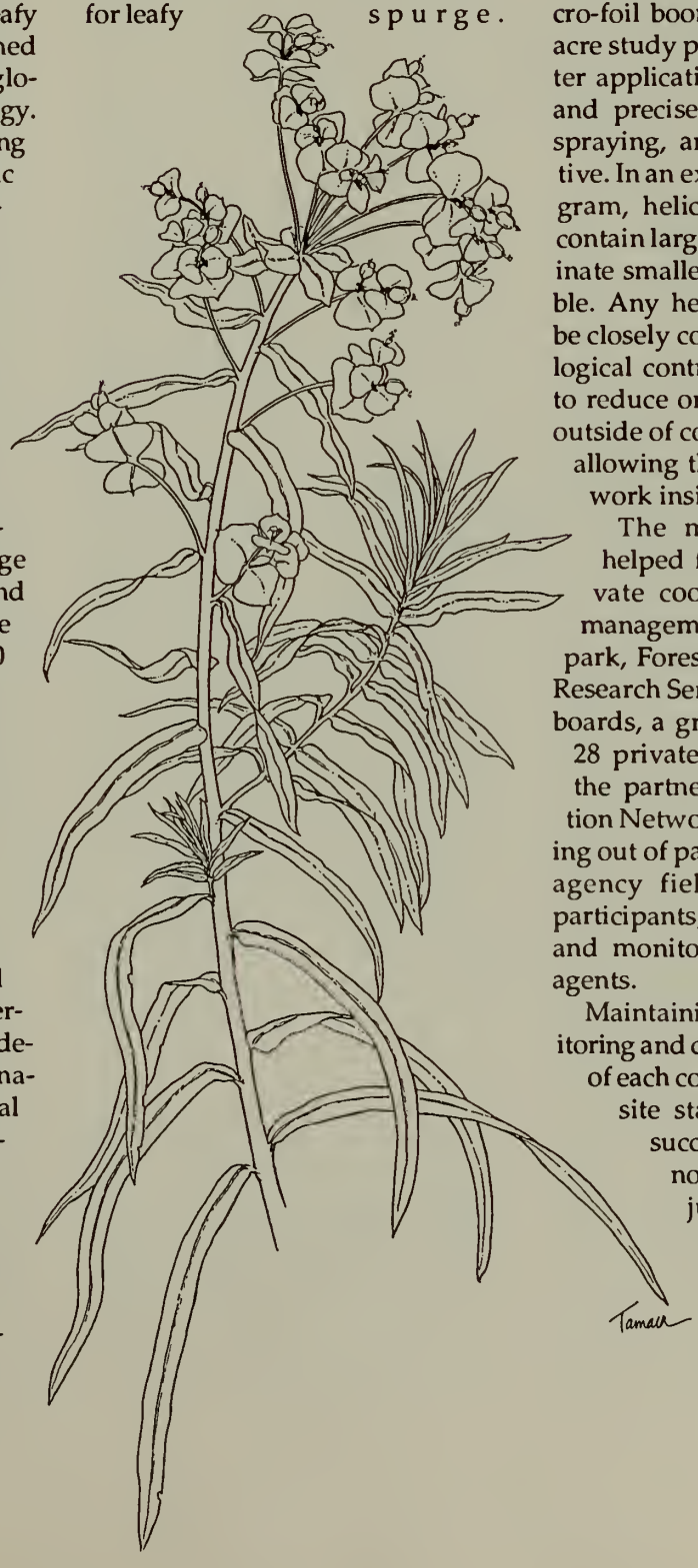
In addition to destroying the rich species diversity unique to the badlands, leafy spurge is also destroying ungulate habitat. Unpalatable to most native animal species, the presence of leafy spurge lowers the availability of forage for wildlife.

Heaviest concentrations of leafy spurge can be found along streambeds, drainages, and wooded draws. Intensive management is required to reduce and contain these infestations while comprehensive and integrated approaches are needed to restore habitat in these areas.

In 1970, managers estimated that 103 separate patches of leafy spurge infested 32 acres of the park. A limited herbicide application program in place since 1975 has had limited success due to the magnitude of the infestations, poor mapping, limited funding for control, and difficult access. Leafy spurge has continued to rapidly colonize non-disturbed sites in the badlands.

Frustrated by a seemingly random control approach both inside the park and on adjacent lands, park managers saw the need for an overall management strategy. To develop control strategies, the park coordinated with the USDA Agricultural Research Service to develop aerial data needed to prepare a geographic information systems (GIS) map. Preliminary data indicated that a minimum of 1,346 acres, or 3% of the landscape, are infested with leafy spurge. Park staff ground-truthed the identified infestations with global positioning system technology. Utilizing the GIS base map along with other existing GIS thematic layers, managers can now develop specific recommendations and strategies geared to a variety of integrated pest management (IPM) techniques.

To begin the development of a cohesive leafy spurge management plan, the Rocky Mountain Elk Foundation teamed up with the park, the U.S. Forest Service, and DowElanco to sponsor the Leafy Spurge Strategic Planning Workshop and Scientific Advisory Panel. The workshop brought together 90 state and federal natural resource managers, scientists, ranchers, farmers, and other interested persons. The scientific advisory panel was asked to evaluate management alternatives and to provide recommendations for implementing a long-term management program consistent with National Park Service and U.S. Forest Service management policies, guidelines, and legal mandates. Alternatives--which included biological control, grazing, mowing, herbicides, and prescribed fire--were evaluated based on environmental sensitivity, safety, and effective IPM techniques. The panel also evaluated previous research and management actions in the park. The resulting recommendations have applications for the park and adjacent public and private lands. How successful the plan will be depends on funding, staffing, and local cooperation. Management actions are necessary to mitigate loss of habitat as a result of exotic infestations. In cooperation with the Agricultural Research Service and the North Dakota Department of Agriculture, the park has established insectaries and expanded experimental biological control programs for leafy spurge.



North Dakota State University has also conducted research and provided biological control agents. (Biological control agents will not eliminate the spurge, but the goal of the management program is to reach an acceptable ecological balance with the native plant communities.) Biological control releases have been made on 137 park sites and shown promising results.

A helicopter equipped with micro-foil booms has sprayed a 200-acre study plot since 1993. Helicopter application was more accurate and precise than boom or hand-spraying, and is very cost-effective. In an expanded herbicide program, helicopter application can contain large infestations and eliminate smaller patches where possible. Any herbicide program must be closely coordinated with all biological control programs, in order to reduce or eliminate infestations outside of containment areas while allowing the biocontrol agents to work inside such areas.

The mapping project has helped foster interagency/private cooperation in the local management of leafy spurge. The park, Forest Service, Agricultural Research Service, two county weed boards, a grazing association, and 28 private individuals comprise the partners in a Weed Innovation Network (WIN) grant. Working out of park headquarters, interagency field personnel trained participants, planned site releases, and monitored biological control agents.

Maintaining consistency in monitoring and developing an overview of each cooperating participant's site status is critical for the success of the program. This noxious weed knows no jurisdictional boundaries. Through joint cooperative efforts a strategy can be developed for managing different levels of infestation within identified watershed basins.

Revegetation with Native Grasses Reduces Soil Erosion and Protects Anasazi Ruins

By Geneva Chong, Colorado State University

Bandelier National Monument contains both cultural and natural resources of breathtaking beauty. Unfortunately, the thousands of Anasazi ruins that fill the piñon-juniper woodlands of Bandelier are being destroyed by rapid rates of soil erosion. Although the locations of many of these sites are recorded, only a few have been studied. For future generations to experience the wonders of this park, and for archaeologists and anthropologists to learn from the ruins, resource managers must reduce the amount of bare soil in the park in order to reduce erosion and thus maintain the cultural and natural resources.

To reduce the amount of bare soil in the park, a study was done to develop methods to increase the groundcover of native grass species. The revegetation methods used in this study were designed for application in remote wilderness areas of the park where management priorities include the maintenance of genetic integrity, the reduction of high rates of soil erosion, and the protection of Anasazi archaeological sites.

Study objectives were to provide the natural resource managers at Bandelier National Monument with (1) revegetation treatment methods to increase the cover of native grass species in the piñon-juniper woodland, (2) a description of the effects of each site's distribution of piñons and junipers on revegetation success, and (3) a description of the periodicity in local precipitation, so that wetter years can be targeted for application of revegetation treatments.

Tree thinning treatments showed the level of competition between trees and grass seedlings. Amendments of slash, straw mulch, and fertilizer demonstrated the suitability of eroded soils for native grass establishment. The addition of seed from five native grass species tested each species' ability to establish. Finally, the effects of the spatial arrangement of trees and interspaces across the landscape and the temporal effects of variable precipitation on grass establishment were examined.

Bare soil away from tree canopies favored grass establishment regardless of thinning or amendment treatments. Tree thinning, soil amendments, and seed addition enhanced seedling establishment. New grass plants were found only where seed was added. At the landscape level, computer simulations showed that the spatial arrangement of tree interspaces interacted with seed dispersal distance to regulate the rate at which grass populations saturate suitable habitats. At the regional level, an analysis of precipitation indicated that managers may be able to avoid planting during dry episodes because their occurrence is statistically predictable.

Thus, even though the soils in the piñon-juniper woodland at Bandelier are eroding rapidly, resource managers may be able to slow the erosion by helping native grasses to re-establish. If the grasses established in this study continue to survive, the soil erosion rates at the study site may be reduced and the Anasazi ruins protected. Through experimental manipulation, observation, and computer simulation at different spatial and temporal scales, the results of this study provide resource managers with prescriptions for increasing the probability of successful revegetation in the piñon-juniper woodland at Bandelier National Monument: (1) add seed; (2) reduce tree cover to 25% and use the slash as a mulch; (3) target bare, eroding areas for revegetation treatment; and (4) apply treatments in winters or springs when a wetter period is predicted.

Resource managers interested in ecosystem management need to look within their system for internal control mechanisms such as the effects of soil conditions on seedling establishment. They also should examine the effects of the history that shaped the site and thus continue to influence it, much as tree density and arrangement affected seedling survival and dispersal. Finally, they should look beyond their system to see what outside forces, like regional precipitation, influence the system. Throughout the resource management process, managers should recognize that important factors operate and interact at different spatial and temporal scales. Anyone can go out and throw seed on the ground, but the plants will establish only if the conditions are right. By helping the resource manager determine how, where and when to plant we can save time, money, and, most importantly, the cultural and natural resources of the park.

Step 3

RESTORE Resources to Natural Conditions and Functioning

The Disturbed Lands Restoration Program

Vera Smith and David Steensen, Geologists, Mining and Minerals Branch

Increasingly, parks are regarded as islands of "natural beauty and process" in a sea of encroaching human development. As much as this analogy is effective in conveying the threats of boundary development, park resource managers are aware that it is not strictly true; park boundaries are not an effective barrier to human influence.

Beginning before parklands were withdrawn for conservation and continuing throughout their management history, parks have been developed. This development can be seen today in a multitude of forms—road networks, river channelization, canals and irrigation ditches, logging skid trails and landings, dams, and mining operations—often from the days before a park was established or in earlier, less sensitve days of public management. The consequences of this development vary from diminished aesthetics to significant and persistent natural resource damage. As the noose of external development tightens around park boundaries, the value of "undisturbed" lands appreciates; the public's demand to maintain the "natural" islands grows and the significance of restoring disturbed lands to a "naturally functioning condition" increases.

The restoration of lands disturbed by human activity involves setting in motion successional processes that will ultimately lead to restored ecosystem function. This does not always mean precisely restoring the predisturbance characteristics, but it does involve establishing geologically and hydrologically stable landscapes capable of supporting the natural ecosystem mosaic. In some cases, natural processes left to themselves will accomplish more than any intervention. In other cases, however, disturbed areas will not recover without intervention even in the scope of geologic time. At sites where intervention is warranted, carefully designed restoration work will significantly accelerate recovery rates.

A reclamation geologist surveys an abandoned mine as part of the restoration design process at the Quinault Quarry in Olympic NP.

Unrestored disturbed lands can negatively affect park resources. Mine sites, for example, can contain and release into the environment heavy metals in toxic concentrations, acid-producing material, and contaminated water. Even mineral material sites such as stone quarries and sand and gravel pits can be detrimental to the environment through the introduction of sediment into waterways; increased sediment yield affects aquatic species by altering water temperature, visibility, and dissolved oxygen concentrations; lowering reproductivity; and destabilizing the river channels. Abandoned or unmaintained road networks also affect water quality with increased erosion and sediment production into riparian systems. For example, Redwood National Park has approximately 300 miles of abandoned road and 3,000 miles of abandoned timber skid trails and landings, all of which have contributed tens of thousands of tons of sediment into Redwood Creek over the past 15 years. The resultant aggradation (infilling) and widening of Redwood Creek threatens to erode and destroy the Tall Trees Grove, the preservation of which was the main reason for the park's initial establishment.

Restoration, and its offspring terms reclamation, rehabilitation, and remediation, are not new words to the National Park Service. Individually, a few parks have been re-

storing disturbed lands within their boundaries for years. The preeminent example is Redwood National Park. Legislative language accompanying a boundary expansion in 1978 mandated that Redwood undertake the restoration of logging roads within the expansion. The Watershed Restoration Program is now regarded as outstanding by agencies and private groups involved with salmon restoration on the west coast. Other parks, such as Yosemite, have established their own restoration program modeled after Redwood's. Denali National Park and Preserve, Cuyahoga Valley National Recreation Area, and Joshua Tree National Park, among several others, are additional examples of parks that perform restoration work.

Because disturbed lands are scattered throughout the National Park System and because most parks and regions do not have staff trained in restoration, the Mining and Minerals Branch created a Disturbed Lands Restoration Program. Program goals include: rehabilitating land and water resources degraded by past land use practices, and restoring natural processes to support in the long term the natural ecosystem mosaic. To date, much of the reclamation work that has been undertaken by the Mining and Minerals Branch has focussed on the reclamation of abandoned mineral land sites (e.g., quarries, metal mines, oil and gas well sites). However, in the past three years, staff have also been involved with the reclamation of abandoned roads, railroad grades, dams, irrigation ditch and canal systems, and the planning and design of the restoration of a major watershed.

The newly established Disturbed Lands Restoration Program is an attempt to concentrate expertise in reclamation and restoration in the Park Service—to combine in one office resource specialists trained in geology, geomorphology, geotechnical engineering, hydrology, soil science, biology, contracting, and heavy equipment operation. The program operates under the axiom that stable landscapes are required for the long-term function of natural systems, and the associated corollary that physical restoration of the land is the fundamental building block for biologic recovery. For example, the reconstruction of natural drainages, stable hillsides, and floodplains dictate surface and groundwater behavior that facilitates the establishment of an appropriate plant community for a site. Revegetating a site without restoring the appropriate physical conditions can lead to failure or less than optimal restoration.

In 1994, the Mining and Minerals Branch designed and managed the restoration of the mining-disturbed areas in the Little Cottonwood Creek watershed in Craters of the Moon National Monument. The major goal of the restoration was to improve the water quality in the watershed, which was degraded by historic mining activity (elevated levels of lead, arsenic, zinc, and cadmium), and to insure compliance with the Clean Water Act and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Because of a limited Park Service budget, the project was achieved by utilizing Bureau of Land Management heavy equipment and operators as well as contracted heavy equipment, and the assistance of a local Boy Scout troop in amending soils, seeding, and mulching. Activities included: landfilling toxic materials, recontouring the slopes to stable configurations, removing abandoned roads, revegetating, and excavating the original stream channel which had been filled by mine tailings and road fill.

As stated in the Organic Act, one of the fundamental missions of the National Park Service is to "...conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." The program goals of the Disturbed Lands Restoration Program embody this mission—we restore the landscape to a stable functioning system in which the watershed, plants, and animals can be reestablished, healing both the scar on the land and the ecological function of the area.

Bison Inspire Creative Prairie Restoration Technique

By Carol Maass, Chief of Resources, Bent's Old Fort NHS

According to old journals, the short grass prairie that surrounds Bent's Old Fort impressed the visitor of the 1800s as much as it surprises the visitor today. Each present-day visitor to the historic site travels a 400-yard trail back into time. To the left of the trail are the riparian zones of the Arkansas River, to the right the upland short grass prairie. In the distance, visitors see expansive views of the river valley walls covered with the treeless brown prairie. For most visitors to the historic site, this will be their most intimate contact with the short grass prairie they have been traversing since western Kansas.

Unfortunately, modern-day visitors on the trail see more exotic weeds than short grass prairie. From the mid-1960s, efforts have been made to restore the native vegetation from agricultural fields in the

area north and west of the reconstructed fort. In one broad area the restoration met with some success, but for the most part failed on the 10' strip that borders the west side of the trail. Here the steep slope from the upland area to the trail had been taken over by exotic annual species of kochia, blue mustard, and russian thistle. These cold season annual weeds suppressed the growth of the warm season prairie grasses. Compounding the problem was the bare 30-45 degree slope that eroded and caused most of the annual 10" rainfall to run off rather than infiltrate the soil surface. Since it is a visitor use area, the weeds were sprayed and mowed to keep vegetation low as a safety precaution against rattlesnakes. Here, in our most visible area, where the site could best illustrate the environmental context of the historic site, unsustainable practices failed to replace undesirable vegetation with desirable short grass prairie.

To correct this problem, the historic site decided to try to replicate the natural action of buffalo hooves, which formed small impressions in the soil that increased water infiltration to the plant roots and protected young plants from the wind. Along the trail, a YCC crew used hand tools to terrace the soil into 2"-4" deep basins or long linear troughs perpendicular to the slope. The bowls and troughs that curved back into the slope held the water, allowing greater infiltration into the soil. Native seed was planted in the basins, mulched with old straw, and the plantings watered using gravity fed hoses from a small tank on a truck. Within two days, superhighways from seed collecting harvester ants wound up the hill, and control methods were introduced to stop the loss of seeds. After one week, seedlings appeared and by frost the basins contained exceptional stands of native grasses.

Maintenance will become more sustainable over time. Initially the use of weed whippers will control the exotic species, until the native grasses choke them out. Eventually, the short prairie grasses will need little to no mowing. Restoration of the forbes and legumes killed by past use of herbicides will restore the species diversity and structure of the native vegetation. For the visitor to the site, a safe trail with a display of native plants will enhance their sense of traveling back in time.

Volunteers Help Remove Tunnel Blasting Debris From Timpanogos Cave System

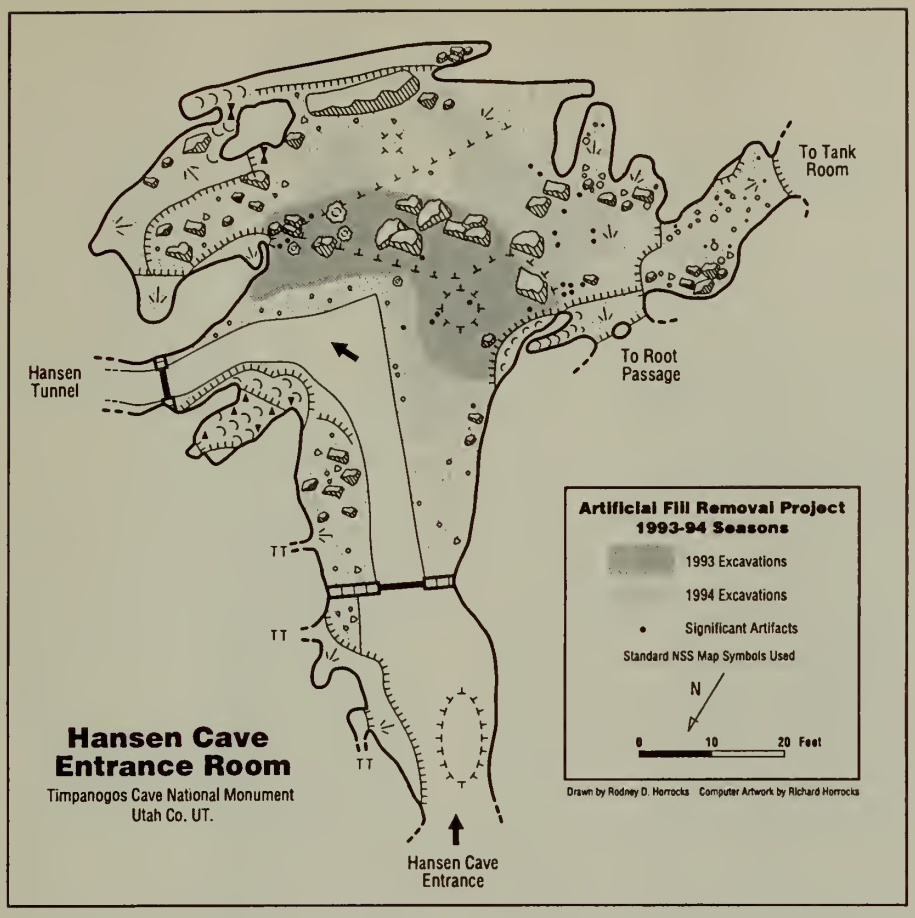
By Rodney D. Horrocks, Resource Management Specialist, and Kathy Brown, Chief, Interpretation and Resource Management, Timpanogos Cave National Monument

In late 1930s, tunnels were blasted to connect the three caves of the Timpanogos Cave system, allowing single-direction cave tours. The hundreds of tons of blasting debris was dumped in pits and used to create level floors in the cave. Although cheaper and more convenient than building elevated walkways, this artificial fill plugged natural drainage routes, buried formations, and altered natural airflow patterns. Filling in the pits also removed some of the natural appeal of the cave experience, diminished the caves' aesthetic quality, and significantly reduced the volume of the caves.

To return the cave system to its natural state, Timpanogos Cave National Monument began an artificial fill removal project in the summer of 1993. The Hansen Cave Entrance Room, the first room seen by visitors on the tour, was chosen for the first phase of this long-term restoration project. One of six major debris-dumping sites in the Timpanogos Cave system, this single room contained an estimated 250 tons of tunnel blasting debris. Debris removal from the Hansen Cave Entrance Room was complicated by the presence of historical artifacts left by an abortive onyx mining effort in 1892-93. Although this venture failed when the company realized that the flowstone was not onyx, many of the formations in the room were broken up and shipped away to unknown sites in the eastern states.

Four goals guided the restoration project: 1) Restore the Hansen Cave Entrance Room to its natural state. 2) Restore hydrologic flow paths clogged with debris. 3) Improve the aesthetic quality of the room for visitors. 4) Provide new material for interpretive programs and exhibits.

In order to complete the project, three things were needed: a little money, a lot of volunteer help, and technical specialists. The money came from the National Park Service's Resource Management Division in the Rocky Mountain Regional Office. The volunteers came from the National Speleological Society, physical science classes in nearby middle schools, Brigham Young



Schematic of debris removal in Hansen Cave Entrance Room at Timpanogos Cave National Monument.

University students, and scout troops. Planning revealed that this type of restoration would involve several disciplines, including speleology, archaeology, photography, and maintenance. The specialists in these fields were solicited from our staff and from a growing list of volunteers. Taking advantage of the recent memorandum of understanding between the National Speleological Society and the National Park Service, Society members helped supervise other volunteers and conducted the more detailed work of uncovering the natural floors of the cave.

The project was divided into two one-month sessions, scheduled during the fall of 1993 and 1994. On the first day, enthusiastic volunteers removed 8.4 tons of debris. Soon, the "treasure-hunting" instinct became a major motivator. As historical artifacts turned up, the discoverer's name was attached and the artifact located on a large-scale map. Another source of excitement came whenever a stalagmite was uncovered and the discoverer started slowly removing debris from a delicate formation that hadn't been seen in fifty-four years. The entire group gathered around to watch the first drops of water fall onto these stalagmites, restarting the long-interrupted deposition process. Watching this process begin again was certainly one of the most rewarding results of the project. As an additional reward for their efforts, each group got a tour through the cave before starting back down the trail.

During the project, a total of 285 volunteers donated 1,741 hours on 16 separate days to remove 121 tons of artificial fill from the Entrance Room in Hansen Cave. This includes a total of 11.15 tons of broken calcite from the 1892-93 mining operations. During the two seasons, 11 stalagmites and many examples of flowstone, popcorn, and breakdown blocks were uncovered on the natural floor of the cave.

The total fill removed so far represents about 1/2 of the fill originally dumped in the room. After the remainder of the fill is removed during the third phase of the project, visitors will view the room from an elevated walkway. Not only will the volume of the room be 1/3 larger, but visitors will be able to see long-buried formations. In addition we will be able to interpret the damage done from the mining operation, stressing the importance of learning from past mistakes and illustrating the evolution of cave management philosophy.

Wetland Restoration Provides Habitat for Threatened Orchid in Utah

By Lynn Riedel, Biologist, Division of Natural Resources, Rocky Mountain Regional Office

A deep, narrow box canyon, with the inelegant name of Hog Canyon, lies in the Utah section of Dinosaur National Monument. Riparian rehabilitation conducted over the last several years in Hog Canyon aims to restore a riparian system, including a wet meadow and habitat for the threatened orchid, Ute ladies' tresses (*Spiranthes diluvialis*).

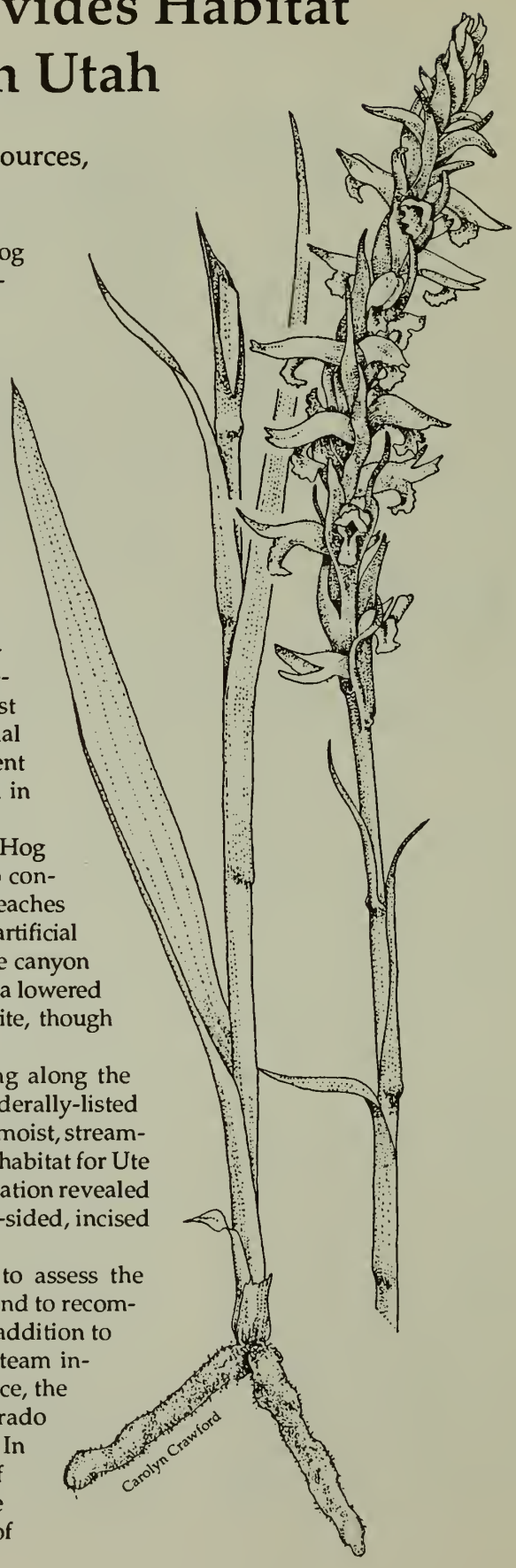
A spring-fed, perennial stream flows along the floor of Hog Canyon, crossing an alluvial fan and contributing to a wetland, wet-meadow complex. This unusually water-rich area, surrounded by drier land, supports diverse plant and animal life. In Dinosaur National Monument, located on the northeastern edge of the Colorado Plateau, such sharp contrasts typify the landscape.

Abundant natural resources and scenic beauty have long attracted people to Hog Canyon. Prehistoric Native Americans left rock art and pit house remnants. Settlers of European origin maintained hay fields and pastures during the last hundred years. The Josie Morris Ranch, listed on the National Register of Historic Places, demonstrates spring development near Hog Canyon. Today, water rights to the small stream in Hog Canyon belong to a ranching family.

Earlier this century, in a small meadow near the mouth of Hog Canyon, settlers constructed an artificial stream channel to control water for downstream irrigation. Today that channel reaches depths of 5' to 6' and averages 1' to 2' in width. The deep, artificial channel acts as a drain and lowers groundwater levels in the canyon meadow. Past grazing practices have intensified the effects of a lowered water table. The meadow vegetation typifies a more xeric site, though remnants of a native wet-meadow community remain.

In 1989, botanists discovered Ute ladies' tresses growing along the stream banks in Hog Canyon. This rare orchid became a federally-listed species with threatened status in 1992. Experts identified the moist, streamside zone along shallow stretches of the stream as important habitat for Ute ladies' tresses. Following the orchid discovery, closer observation revealed the human-caused changes in the stream channel. The steep-sided, incised channel provides very little orchid habitat.

An interdisciplinary advisory team convened in 1990 to assess the probable departure from natural conditions in the canyon, and to recommend monitoring, mitigation, and management actions. In addition to National Park Service staff, the interdisciplinary advisory team includes representatives from the U.S. Fish and Wildlife Service, the Chew Ranch, the U.S. Soil Conservation Service, the Colorado State Natural Areas Program, and the U.S. Forest Service. In 1991, Park Service staff initiated intensive monitoring of vegetation, surface water, and subsurface water. Resource management personnel established a demographic study of



Ute ladies' tresses involving permanently marked plants. The NPS Water Resources Division supported the work with guidance and partial funding. Following baseline data collection, the advisory team developed a restoration plan with the primary goals of relocating the stream into a more native course, re-establishing a wet-meadow community, and providing additional habitat for the threatened orchid.

In 1993, upon completion of all required consultation, Dinosaur National Monument and the Water Resources Division staff installed a relocation structure in the stream channel immediately upstream from the incised section. A new pilot channel led the streamflow onto the surface of the alluvial fan where the stream meandered along a native course in lower Hog Canyon.

The results of regular monitoring during 1994 indicate a significant, persistent rise in groundwater levels in the lower canyon following the stream relocation. Sampling results confirmed significant soil moisture increases in root zones. Streamflow measurements showed that the downstream yield for the water right holder was unaffected by the project.

About 30 orchid plants, which occurred along the abandoned channel, provided opportunity for experimentation. During the summer of 1994, resource management staff transplanted approximately 1/3 of those plants to newly-created habitat, relocated 1/3 in previously known orchid habitat, and left 1/3 in place. Long-term monitoring will document the orchids' survival. This study plan was approved through Endangered Species Act, Section 7 consultation, and should yield important information on habitat requirements for the species.

The restoration project is scheduled for completion in fiscal year 1995. Remaining activities include filling the incised channel (groundwater drain), continuing groundwater and streamflow monitoring and orchid demographic study, soil moisture sampling, channel erosion monitoring, documentation of vegetation changes, development of interpretive materials, and completion and distribution of a final report on the restoration project. Long-term monitoring will include annual orchid monitoring, periodic vegetation sampling, and groundwater and streamflow monitoring.

The project designers recognize that the ecological boundaries of this riparian system extend far beyond the canyon walls. The ongoing success of stream restoration in Hog Canyon will be directly related to the effectiveness of landscape level planning in Dinosaur National Monument and its biogeographical setting. For example, the Ute ladies' tresses orchid occurs where natural disturbances like flooding and seasonal native ungulate use have been important factors through time. The recovery and maintenance of this rare species and its habitat require watershed and ecosystem level management that promotes naturally functioning processes.

Additional, challenging requirements for effective long-term management of the Hog Canyon area include integration of natural and cultural resource planning, multidisciplinary interpretation, and proactive planning for inevitable increases in visitation. Successful endeavors to restore, maintain, study, and enjoy similarly diverse areas throughout the National Park System must address these elements of holistic park management.

Volunteers Aid in Rare Plant Management

By The Presidio Natural Resource Management Team, Golden Gate National Recreation Area

On October 1, 1994, the Presidio of San Francisco became part of the Golden Gate National Recreation Area. Although most of the attention has been focused on the Presidio's historic values, the transition from army base to park represents a significant contribution of open space and natural area to the National Park System.

Eleven of the thirteen native plant communities in the Presidio are considered rare or are declining rapidly in the state of California, and eleven rare and endangered plant species are found in the sand dunes and serpentine grasslands. This high number of rare species may be due to the fact that the Presidio is one of the few remaining islands of native habitat in an otherwise urban San Francisco peninsula. Massive loss of habitat in the Bay Area has made once-widespread species far less common, and within the Presidio itself, the rare plant habitats are isolated in small, vulnerable patches.

One rare species of particular concern is the proposed federally endangered San Francisco lessingia (*Lessingia germanorum*). This delicately branching annual has lemon-yellow composite flowers that bloom in the fall. Five of the last six remaining populations of lessingia occur in the Presidio's remnant dune habitats. It is found in the semi-stabilized backdunes, just inland of the foredunes.

The natural process of sand movement by wind, which results

in dune blow-outs, is necessary for the creation of the open sand patches that lessingia colonizes. One of the threats to the survival of this species is the obstruction of wind movement across the dune system by buildings and trees, which interrupts this natural process. Because the Presidio's planted forest (consisting solely of exotic trees) is historically significant, the balance between the management of natural and cultural resource values has been a challenge. Fortunately, in some cases removal of the trees that have "escaped" beyond the original 1880s planting plan restores the historic boundaries of the forest and opens up sand dune habitat.

The recovery of lessingia involves the restoration of enough sand dune habitat to enable natural processes to occur, ensuring the self-sustainability of the plant community. The construction of a pipeline through a former ballfield in the Presidio by the City of San Francisco has afforded the Park Service the opportunity to restore 10 acres of lessingia habitat. Tunneling for the pipeline, which is located in the vicinity of the native dune, has left a tremendous stockpile of sand. This sand will be contoured into low hillocks and swales to match the topography of a natural dune system and then planted and seeded with dune species, including the lessingia.

A weekly, drop-in volunteer work party provides much of the restoration labor, as well as some monitoring and site planning help. The San Francisco Conservation Corps, school groups, and corporate groups help rid large areas of invasive exotic vegetation, such as ice plant.

Park resource managers are also attempting to learn as much as possible about lessingia and what conditions are most favorable for its regeneration. It is often difficult to assess the site characteristics and plant community composition that will help promote lessingia, due to the highly disturbed condition of the few sites in the Presidio. Baseline information on lessingia's population dynamics is being gathered by natural resource managers, assisted by volunteer groups such as the Garden Club of America.
Long-term monitoring of the dunes will enable us to assess the effectiveness of our management efforts. It is conceivable that as the restored plant community establishes and thrives, lessingia may be crowded out by larger, woody shrubs. In the future, we may be faced with the need to clear openings for lessingia to colonize, but the hope is that the dynamics of the restored system will be self-sustaining.

YCC Adds to Resource Management

By Wayne Rose, Park Ranger, Catoctin Mountain Park

The Youth Conservation Corps (YCC) gives young people hands-on experience in the field of conservation. When these workers turn to resource management activities, the rewards can be substantial to everyone involved.

For the past two years at Catoctin Mountain Park, the YCC has operated out of the Resource Management Division. The first week is spent on training the enrollees on safety, resource management activities, and map and compass use, as well as camp rules and park policy. Then comes the more specific resource management training.

This past summer enrollees received instruction on the life cycle of the gypsy moth and how this insect pest negatively affects the forest environment. They then assisted the IPM Coordinator in placing 88 male moth traps over the 5,770 acres of park land. The trap sites are located on a 500 meter grid system and the enrollees had to utilize their map and compass skills to locate these sites. At the end of the summer the traps were revisited and the male moths were counted. This data is utilized for the purpose of monitoring the gypsy moth population to determine if control will be needed the following year.

The enrollees also learned to identify species of fish and conducted a trout population survey on two major trout streams utilizing electroshocking equipment. They improved stream habitat by stabilizing stream banks with stones and removing log jams. The Resource Management Assistant conducted a session on monitoring stream water quality in Catoctin's trout streams.

Exotic plants continue to be a problem in the park and are choking out native vegetation. YCC members became familiar with several varieties of exotic plants and spent time mapping the location of tree of heaven and Ohio buckeye, and mechanically removing several acres of these invasive plants.

Catoctin Mountain Park receives high visitation and is showing signs of visitor impact on park trails, picnic areas, and camp grounds in the form of erosion and compaction. The YCC members worked on trail restoration by installing water bars, filling in gullies, and placing wood chips on trail surfaces. They replanted native vegetation in compacted areas.

Working with the YCC is a rewarding experience and with good leadership a resource management program can gain a lot.

Step 4

PROTECT Resources and Natural Systems

Reserved Water Rights Secured at Rocky Mountain National Park

By Ken Czarnowski, Park Hydrologist, Rocky Mountain National Park

Adjudication action initiated in December 1976 under the "McCarran Amendment" provided the only opportunity for the United States to quantify and secure recognition of federally reserved water rights in the South Platte Drainage within Rocky Mountain National Park. The United States, on behalf of the National Park Service, filed a claim with the adjudication court for "all waters located in, on, under, adjacent or otherwise appurtenant to the lands withdrawn from the public domain for national park purposes."

The filing and subsequent amendments for federally reserved water rights did not quantify specific amounts of water as necessary for national park purposes. Rather, the United States claimed "quantities of surface, ground, and underground waters, both tributary and non-tributary,...to fulfill the purposes for which the reservation was created...." Because of the non-specific nature of the amounts of water sought by the United States for the park, opponents recommended against approval unless the "applicant (United States) submits evidence to the Court proving flow rates and details of historic use."

Rocky Mountain National Park was created on January 26, 1915, from lands previously reserved and set aside as national forest lands and enlarged through a series of land acquisitions, exchanges, transfers, and boundary adjustments. The original reservation legislation and the 1916 Act to Establish a National Park Service describe the purposes for the reservation of Rocky Mountain National Park. The purposes contained in the 1915 Act were "primarily aimed at the freest use of said park for recreation purposes by the public and for the preservation of the natural conditions and scenic beauties thereof." In the 1916 Act, Congress directed the National Park Service to manage national parks, monuments and reservations for "the fundamental purpose of the said parks, monuments and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

In November 1992, the Department of Justice presented oral arguments in State Water Court in support of a Motion for Summary Judgement for its claimed water rights. A Motion for Summary Judgement asks the Court to render a decision based only on the law, because there are no material facts at issue. Opposition to the Motion was presented by the Colorado Attorney General, the Northern Colorado Water Conservancy District, the City and County of Denver, and other water users along Colorado's Front Range.

The Court's decision on the Motion relied upon scientific facts and points of law raised in an earlier Forest Service case involving reserved water rights for national forest purposes heard by the same judge, but with a different result. The Forest Service lost its case. However, the national forest and the park had vastly different purposes as defined in their organic legislation. According to the courts, national forests were reserved for only two purposes--"to conserve the water flows and to furnish a continuous supply of timber for the people." National forests were not to be reserved for aesthetic, environmental, recreational, or wildlife preservation purposes.

In the Rocky Mountain Park case, the Court stated that stream flow alteration affects channels and "interruption or reduction of natural flows as a result of diversions would be contrary to preservation of the scenic beauties." The Court also analyzed the relevant portions of park's enabling legislation and 16 U.S.C. 1 and concluded that Congress, in setting aside Rocky Mountain National Park, "intended to reserve all of the unappropriated water in the park for park purposes. Only by doing so can the underlying purposes of the creation of the park be achieved. The fact that the entire flow is needed is sufficient quantification of the right."

On October 12, 1994, the Court issued a final decree for Rocky Mountain National Park's reserved water rights, which was not appealed. This favorable ruling is clearly precedent-setting, but only in Water Division No. I. However, this decision is likely to influence future reserved rights decisions in Colorado and neighboring states.

With respect to the decree, Rocky Mountain National Park Superintendent Homer Rouse stated, "This is a fitting climax to nearly two decades of hard work and dedication by a number of individuals both within and outside the National Park Service. This ruling will make our job much easier in preserving the natural conditions and scenic beauties of the park."

An Ootheca* in Building #51: Managing German Cockroaches With IPM

By Jobe Chakuchin, Resources Manager and IPM Coordinator, Lisa Eckert, Assistant Chief Naturalist, Denali National Park and Preserve, and Carol DiSalvo, IPM Assistant, Wildlife and Vegetation Division

An exotic species made its way into an employee residential apartment building (#51) in Alaska in the early 1980s. This species, the German cockroach probably arrived in the boxes of a transferring Everglades employee. Managing this species in Denali is important for several reasons. Roaches are not endemic to Denali, although they frequently enter Alaska via stored products and groceries from the Lower 48. Roaches may also carry disease, and they definitely affect employee morale.

Although the park had been baiting the cockroaches with Combat Bait stations since they were first spotted, resident complaints of cockroach sightings increased through the years. The bait stations probably failed due to the abundance of other available food and moisture sources. So, in 1992 the park staff decided to implement integrated pest management (IPM) methods.

An essential step in any IPM program is species determination. Sticky traps were used to trap the roaches, which were identified as German cockroaches. In order to understand the magnitude of the problem, sticky traps were set throughout the facility to determine population levels and to detect "hot spots" or areas where roaches were more abundant. During a two-week period in April 1993, we caught four roaches in one apartment. However, during 55 days between October and December 1993, the traps in another apartment yielded 312 cockroaches.

Obviously, populations were indeed high. The established action threshold (or number of roaches that triggers management efforts) is two roaches/trap/night. On to the next management step: a careful cleaning plan that included immediate trash removal, kitchen clean-up, reducing moisture sources, and educating the occupants. We continued to monitor the population, again using sticky traps. In 59 days between January and March 1994, only 80 roaches were trapped, putting the roach population under the established action threshold.

Residents wished to decrease the roach population further. Hot spots were determined with sticky trap monitoring. All six apartments and the basement recreation hall were given a crack and crevice treatment with boric acid dust from late March to mid-May of that year. Management actions involved cleaning, dusting cracks and crevices with boric acid, and caulking cracks and holes with a silicone-based sealant and were concentrated on areas along the kitchen floor, baseboards, cupboards and counters, sink area, heater pipe units in the kitchen, bathrooms, the stairwell to the basement, and the basement.

An ootheca is the cockroach egg case. German cockroach egg cases contain 40 eggs.

Fundamentals of Integrated Pest Management

1. *Build consensus.*
2. *Establish objectives and priorities.*
3. *Identify pests and determine distribution.*
4. *Establish action thresholds.*
5. *Monitor pests and environment.*
6. *Apply non-chemical management.*
7. *Obtain approval and apply pesticides.*
8. *Evaluate--continue monitoring.*
9. *Keep records (Pesticide Use Logs).*

Although time-consuming, caulking is well worth the effort as it permanently reduces pest entry routes. The stairwell to the basement and accessible holes in the walls were carefully caulked. Most holes for water pipes were only dusted with boric acid and not caulked because of the large amounts of caulk required to finish the job. Other methods of covering large holes will have to be explored, such as installation of metal flash-

ing, cement, or blow-in foam. In the kitchen, large holes were covered with duct tape and caulked along the edges of the tape to create a semi-permanent exclusion. This is only a short-term solution, as the duct tape will eventually deteriorate. Long-term goals include thorough exclusion to be accomplished by the Maintenance Division.

Working closely with the Maintenance Division greatly increased the effectiveness of the cockroach management program. Whenever possible, the crack and crevice treatment was combined with routine maintenance work in some of the apartments. A couple of kitchens and bathrooms were scheduled to be renovated, so treatments were scheduled accordingly, allowing more thorough and integrated treatments in these areas.

Combat Bait trays were set out and further touch-ups with boric acid powder and silicone sealant applied as dictated by sticky trap counts in October 1994. The result of our cockroach-proofing was a dramatic decrease in roach sightings. In fact, there were no reported sightings until early November.

Although the initial crack and crevice treatment is time intensive, it requires less time for further touch-ups. Regular monthly monitoring for one overnight period will begin this season. In addition, education of residents on proper food storage and tidiness will continue.

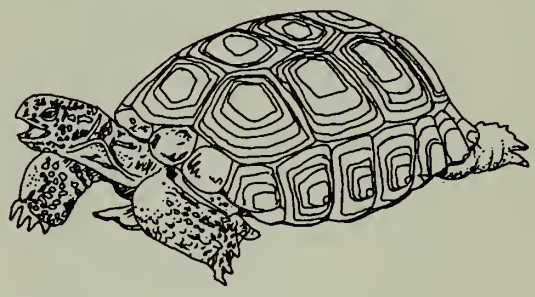
The 1980s roach population increased due to a reliance on pesticide alone (bait stations), which only treats the symptoms. To eliminate the roach population, it was necessary to address the actual problem: habitat management, available moisture, and food sources. Through an integrated pest management approach, Denali is successfully managing its cockroach problem.

Tortoises Protected Through HCP Partnership

Kent Turner, Chief, Resource Management Division, Lake Mead National Recreation Area

In 1990, Lake Mead National Recreation Area formally began participation in the Habitat Conservation Plan (HCP) for the federally listed desert tortoise in Clark County, Nevada. The HCP process allows more flexibility in addressing actions that could adversely affect individual tortoises, including "taking" listed species in exchange for habitat conservation measures.

The current interim HCP for Clark County will end July 31, 1995, and the long-term Clark County Desert Conservation Plan will become effective for 30 years. This long-term HCP allows construction within desert tortoise habitat in Las Vegas Valley in return for the provision of conservation measures and management funding by developers across approximately 500,000 acres of federal lands in Clark County, including approximately 180,000 acres of lands within Lake Mead National Recreation Area. The Clark County Desert Conservation Plan also provides for conservation planning and management to address the needs of certain sensitive plant and wildlife species.



Leslie de Beauchamp

Lake Mead participates on steering and technical advisory committees with representatives from the cities of Las Vegas, North Las Vegas, Henderson, and Boulder City, Clark County, the Bureau of Land Management, the U.S. Fish and Wildlife Service, The Nature Conservancy, the Environmental Defense Fund, and user groups. Funding for the HCP comes from a development assessment of $550 per acre in desert tortoise habitat in Clark County. Presently, an approximately $3,000,000 trust fund provides for tortoise management for the life of the permit.

Lake Mead became involved in this process because of the realization that the HCP process would become a major land use plan for southern Nevada. The park has received many additional benefits to resource management within the park as a result of involvement in the planning process. These include: removal of grazing (licenses purchased by The Nature Conservancy with HCP funds) from over 150,000 acres in Lake Mead, incorporation of compatible uses on adjoining Bureau of Land Management lands along approximately 60 miles of park boundary, management funding for removal of approximately 60 feral burros from park lands, and funding for tortoise monitoring and management. Beginning in FY95 this process will provide annual funds to support enhanced law enforcement in tortoise habitat within the park and to conduct multi-species inventories. Perhaps more significantly, this has lead to multi-species ecosystem management across hundreds of thousands of acres of federally managed lands in southern Nevada.

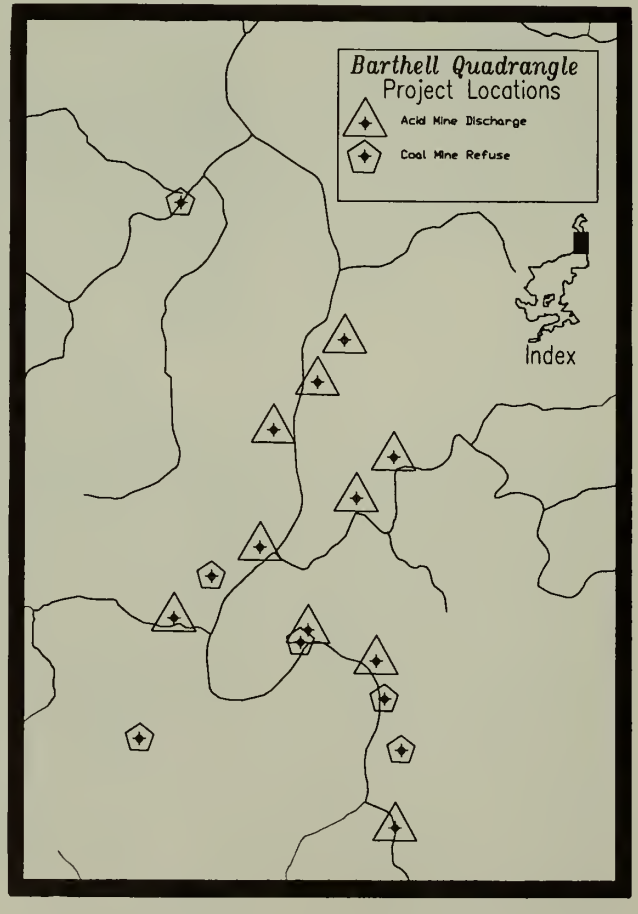
NRPP Makes a Difference in Resource Management

Big South Fork to Restore Sites Along the River Affected by Acid Mine Drainage

By Myra L. Marcum, Secretary, Resource Management Division, Big South Fork National River and Recreation Area

The Big South Fork of the Cumberland River passes through 90 miles of scenic gorges in southeastern Kentucky and northeastern Tennessee. The Big South Fork National River and Recreation Area (NRRA) was established in 1974 to preserve the area's natural and cultural resources, while improving the region's recreational potential. Left over from 60 years of mining activity, acid mine drainage threatens the most vital resource of the Big South Fork NRRA: its water.

Past and present mining practices discharge a complex of heavy metals and other chemicals into streams and onto the landscape. With over one hundred abandoned mines inside or near the boundaries of the Big South Fork NRRA, acid mine drainage has contributed heavily to the deterioration of the overall quality in park waters. In fact, water quality data gathered within the past 10 years indicate that two tons of iron may be unloaded yearly into the main river system from one mine alone.



Project locations for acid mine drainage at Big South Fork National River and Recreation Area

Acid mine drainage affects water quality in countless ways. The drainage increases acidity and the amount of heavy metals, suspended solids, and dissolved solids in the water, as well as decreasing the stream's buffering capacity. This change in the aquatic environment then either diminishes or destroys the organisms in the streams. In the waters of the Big South Fork NRRA, the number of aquatic organisms has decreased significantly. These waters were once home to more than forty-five species of fresh water mussels, as well as numerous other aquatic organisms. Now, at least ten mussel species are thought to be extinct in those areas that have experienced substantial amounts of acid mine drainage.

To counteract this stream imbalance and thus renew its aquatic resources, Big South Fork NRRA has developed the Acid Mine Drainage Watershed Restoration Project. Initiated by park Biologist Steve Bakaletz, the project is funded by the Natural Resource Preservation Program. Collaborating with several state and federal agencies will lessen the cost of the project. The U.S. Bureau of Mines will contribute a major portion of the funds needed for chemical analysis of targeted sites. The State of Kentucky will be partially responsible for the analysis and documentation of water samples taken from the coal mines. The Tennessee Department of Environment and Conservation

will assist with the engineering and design of the chosen treatment system, an anoxic alkaline drain treatment system developed by their biologists. And the U.S. Fish and Wildlife Service will lend assistance with the biological evaluation and monitoring of freshwater mussels and other aquatic organisms.

Even with this wide array of expertise, it is not feasible to treat every stream and tributary affected by acid mine drainage. For this reason, the middle 12 miles of the Big South Fork--the most heavily damaged area of river system--have been targeted for cleanup. This section of the river contains the greatest number of abandoned coal mines in relation to the number of miles it spans. (See Figure 1.) The orange-hued tributaries adjoining this portion of the river provide a daily reminder of the high levels of iron, manganese, aluminum, and sulfur draining into them by seepage through mine openings and gob piles, or mine tailings. To ensure success in ameliorating the effects of acid mine drainage in these targeted streams, project managers plan to take the following plan of action. 1) Create of a set of cross-referenced, comprehensive maps of all acid mine drainage sites. 2) Develop a monitoring program that will characterize the nature of each acid mine drainage site. 3) Complete the design and actual construction of a treatment system as recommended by the chosen contractor. 4) Treat each prioritized site individually, according to need.

Sixty years or more of damage cannot be reversed overnight. Taking into consideration the amount of technology and information already on hand, the above three phases could be completed within the next five years. At its completion, the Acid Mine Drainage Watershed Restoration Project will have begun to restore the ecological balance of the Big South Fork system.

Black-footed Ferret Released Into Badlands National Park

By Dr. Glenn E. Plumb, Wildlife Biologist, and Bruce Bessken, Chief of Resources Management, Badlands National Park

In direct consequence of the blunt treatment of its habitat over the past century, the black-footed ferret is the most endangered terrestrial mammal of North America. Unique among weasels in its highly specialized dependence on a single type of habitat, this member of the Mustelid family relies on the burrows of prairie dog colonies for shelter, family rearing, escape from predators and access to its primary prey, the prairie dog. Unfortunately for both prairie dogs and the black-footed ferrets, prairie dogs now occupy less than 5% of their former range.

Yet biologists think that there may still exist several prairie dog colony complexes large enough to support geographically separate but viable ferret populations. The Conata Basin/Badlands prairie dog complex in southwestern South Dakota includes approximately 9,200 acres of protected prairie dog colonies in Badlands National Park and the Buffalo Gap National Grasslands. With an additional 283,000 acres of dispersal habitat, this complex rates nationally among the finest sites for reestablishment of the black-footed ferret.

In 1994, over twenty-five years after the last known record of the black-footed ferret in Badlands National Park, an interagency environmental impact statement by the National Park Service, U.S. Forest Service, and U.S. Fish and Wildlife Service addressed black-footed ferret reintroduction into the Conata Basin/Badlands prairie dog complex. A final rule, published on Au-

gust 18, 1994, by the Fish and Wildlife Service designated a non-essential, experimental population area for this complex. Subsequently, each agency signed a separate record of decision to implement the preferred alternative to initially reintroduce black-footed ferrets in Badlands National Park in fall 1994.

During spring 1994, three black-tailed prairie dog colonies, totaling 1,025 acres, were selected as locales to release ferrets based on quality of habitat, juxtaposition within the complex, remoteness from visitors, and accessibility for field crews. Ferrets were released within the Badlands Wilderness Area, where approximately 550 bison range freely. A helicopter airlifted over four tons of supplies used for construction of 28 release cages/bison exclosures several months before the ferrets arrival. Thirty-two juveniles (20 males:12 females) and four three-year adults (2 males:2 females) were released from September 19 through November 14. Of these, 17 were pre-conditioned to prairie dogs and burrow systems and 19 were naive (cage) reared. Project biologists fit radio telemetry collars on 16 ferrets to monitor post-release behavior. Naive animals remained in release cages for a minimum of 10 days, with a minimum five-day post-release cage attending interval (soft release). Pre-conditioned animals remained in a release cage for a maximum of 48 hours with no post-release cage attending (semi-hard release).

Post-release monitoring was initiated on September 19 and concluded on December 11. Through a combination of nocturnal aerial and ground telemetry conducted for 21 days post-release, 62 individual locations were detected. Of these, 97% occurred within the three release colonies. Animals moved freely among the three release colonies, but dispersal within three weeks after release was limited primarily to less than 5 miles. Post-release spotlight surveys were conducted from November 28 to December 10. Eight individual animals were detected, representing a minimum 22% survivorship 26 days after the last animal was released. This minimum measure exceeds the 30-day post-release survivorship goal of 20%. Post-release duration ranged from 21 to 82 days for the four males and three females identified by their transponder chip, with 71% being pre-conditioned animals. Not all colonies in the reintroduction area were surveyed, however, and the potential exists for additional animals to be detected in further survey efforts.

Attempting to recover the black-footed ferret populations to the point of delisting is an extremely daunting task. Habitat lost during the last century is not likely recoverable. Prairie dog ecosystems of the Great Plains continue to erode and fragment. Special efforts like the interagency Conata Basin/Badlands project do make a tremendous contribution. However, a fundamental question remains: Can black-footed ferrets persist in the wild today and in the future under the same types of regional land use practices that rendered them nearly extinct? Hope for the black-footed ferret lies in the continuation of a strong but flexible Endangered Species Act in combination with a commitment to conserve a regional prairie dog ecosystem that can support geographically separate yet viable populations of those species so highly dependent on prairie dogs.

Peregrine Falcons Fledge in Shenandoah National Park

By Keith Watson, Resource Management Specialist, Shenandoah National Park

After several years of efforts to reintroduce the peregrine falcon to Shenandoah National Park, two peregrine falcons were produced and fledged in the park this spring. This is the first time peregrines have successfully reproduced in the mountains of Virginia since the early 1960s and in the park since the mid-1950s. To make the success even sweeter, the adult female was identified as T18T, a falcon that was released from Franklin Cliffs in the park in 1991.

The reintroduction efforts in Shenandoah began in 1989 in response to the national effort of the Eastern Peregrine Falcon Recovery Team to restore peregrine falcons to their former range. Financial support was obtained from the National Park Service's Natural Resource Preservation Program. Shenandoah National Park, the Peregrine Fund, the U.S. Fish and Wildlife Service, the College of William and Mary, and the Virginia Department of Game and Inland Fisheries Non-Game Section (VGDIF) all participated in the effort.

In 1989, seven peregrine chicks were released from Hawksbill Mountain, the highest peak in the park. Eight and fourteen chicks were released the following two years, respectively, including one group of six chicks released from a new site at Franklin Cliffs in 1991. Five and eight falcons were released in 1992 and 1993 respectively. A total of forty-two peregrine chicks were released from the park. Thirty-seven are known to have fledged successfully while three known

deaths occurred (one from a predator, one from a collision with a building, one from emaciation after dispersal), and two dispersed prematurely from the site.

In 1994, early peregrine falcon activity was noted in a remote section of the Old Rag Mountain area of the Central District. Subsequent observations determined that an adult pair had selected a nest site and was incubating eggs. The female had a green left leg band. It was truly a sensational spectacle to watch and listen as the adults conducted aerial food transfers, plucked and ate their prey, switched incubation duties, drove off intruders, and performed other aerial acrobatic maneuvers. The site was closely monitored for about 30 days, when the site was suddenly abandoned by the pair. Two unhatched eggs remained in the nest. The eggs were collected by the U.S. Fish and Wildlife Service for analysis. The adults were not seen again at the site. No further efforts were made to locate the pair.

Initial analysis showed that fertilization had probably occurred and partial embryonic development was present. Based on egg placement on the site and rainfall pattern of the time period, it is likely that a rain saturated crevice prevented the adults from maintaining incubation and development temperatures. Some disappointment followed, as this activity represented the first peregrine falcon nest attempt in the park since the mid-1950s.

Later that summer, on a hot, sultry afternoon in late July, a report came in that a pair of peregrine falcons were dive-bombing some visitors on Stony Man Cliffs. Little confidence existed that this report was more than the usual peregrine falcon report—they often turn out to be raucous ravens, broad-winged hawks, or another raptor encounter. But as the site was investigated, the first observation made was of a female peregrine falcon perched on the cliffs of Stony Man. Further investigation and close encounters with two agitated and aggressive adults revealed the location of a cliff nest with two chicks present, still in downy feathers.

Researchers band the legs of four-week-old falcon chicks before placing them in a hack box on Hawksbill Mountain.

Imagine the surprise and astonishment to find 24-day-old peregrine falcon chicks at one of the most popular hiking destinations in the park. The park superintendent wrote a congratulatory letter to the visitors who reported the sighting and later sent them a photograph of the two chicks in their nest.

The adult peregrines made it clear that the visit to the nest was unwanted. Cooperators and park staff were notified, and the effort to ensure the protection of this site ensued. The two chicks, a male and a female, were banded and estimated to be approximately 24 days old, in good health; they appeared to be eating well. For the following five weeks, resource management personnel stationed on Stony Man summit recorded observations and provided additional security to the site. By early September, the young had fledged and were conducting longer and longer forays from their nest area until mid-September, when they began their peregrinations to places unknown.

Several times during the summer, a green leg band was noted on the female's left leg. Her leg band was later identified through a spotting scope as T18T, a female that had been released in 1991 from Franklin Cliffs. Could this be the same female that attempted nesting in the Old Rag area earlier in 1994? Is it coincidence that apparently two eggs were laid at each site? Is it coincidence that three weeks lapsed between the first nest abandonment and laying of the second group of two eggs (the usual time for nest site selection and egg laying)? We will never know positively, but the evidence does suggest that this pair is the same pair that attempted to nest in the Old Rag area.

Bent's Old Fort Fights Tamarisk Invasion

By Fran Pannebaker, Museum Aide, Bent's Old Fort National Historic Site

The woody shrub tamarisk threatens to destroy native riparian plant communities and dry up rivers and watercourses throughout the west. Originally from the Mediterranean and the Middle East, tamarisk was introduced into the United States in the early 1800s as an ornamental and windbreak species. Although millions of dollars have been spent to eradicate tamarisk in the western states, the shrub continues to expand its range rapidly.

When not controlled, tamarisk forms dense, mono-specific stands along and around rivers, springs, and any area that receives higher than normal surface or subsurface water. These thick stands cause severe problems. Tamarisk consumes large amounts of groundwater, increases sedimentation of stream channels, increases salinization in occupied habitats, and destroys native plant communities and the habitats of native animals.

When Bent's Old Fort National Historic Site became park of the National Park System in 1965, tamarisk was already established on many of its riparian acres. During the late 1960s park staff deep-root pruned the tamarisk with a bulldozer in about 90 wetland acres. The best control method known at that time, bulldozing effectively eliminated the tamarisk from that area, but may have done damage to undocumented archeological sites. During the 1970s, there was no funding for natural resource management problems other than weed control and tamarisk was not considered to be a significant problem.

In the late 1980s it became apparent that tamarisk was outcompeting the native riparian vegetation in the park. Tamarisk had infested approximately 100 acres heavily and another 200 acres lightly to moderately. The plant's shrub-like appearance and thick growth habit, so unlike the more open cottonwood and native willow growth pattern, had begun to dominate the historic viewshed.

Maintenance of the historic scene by the elimination of exotic vegetation and restoration of native species is integral to preserving and interpreting this site. Although funds were not available and personnel in small parks was not sufficient to control the problem, the park realized that they had to begin to try to control the problem. As Edmund Burkes' pointed out, "Nobody makes a greater mistake than he who did nothing because he could only do a little."

Nobody makes a greater mistake than he who did nothing because he could only do a little.

Working together, resource management and maintenance personnel have managed to keep tamarisk out of the wetland area. To get an idea of the scope of the problem, the Colorado Natural Heritage Program, University of Colorado, prepared a vegetation map of the historic site using infrared aerial photography and GIS technology. A global positioning system was used to ground truth the vegetation types. This map will be used as a baseline to track the success of tamarisk control methods and regeneration of native vegetation.

The park then began looking for additional help to begin taking control of the problem. In 1992, Eagle Scouts cut and treated with herbicide 353 tamarisk bushes. A check in 1993 showed the control rate at 98.6%. Encouraged by the success of this first small project, the park used NRPP funding to hire a YCC crew during the summer of 1994 to cut and treat tamarisk using hand tools to lop and drop. Junior Rangers and Boy Scouts stacked the cuttings for park maintenance personnel to burn.

The most encouraging development is how dramatically these small scale projects have affected the viewshed of the fort. The open woodland landscape characteristic of native cottonwood is beginning to reappear in the areas nearest the fort.

Using the knowledge gained from these tremendously successful small-scale projects, a Tamarisk Control Plan has been prepared to direct specific treatment methods for each vegetation unit and to set priorities for the order of treatment. Amount of damage already done to native vegetation, affect on the historic viewshed, and accessibility and proximity to the fort itself were criteria used to decide the work schedule in the future. Resource management and maintenance crews are optimistic that each year, with cooperative efforts between park divisions and with the help of volunteers, control efforts will reduce tamarisk in the park and restore the historic scene.

The Public Helps Us Protect Resources

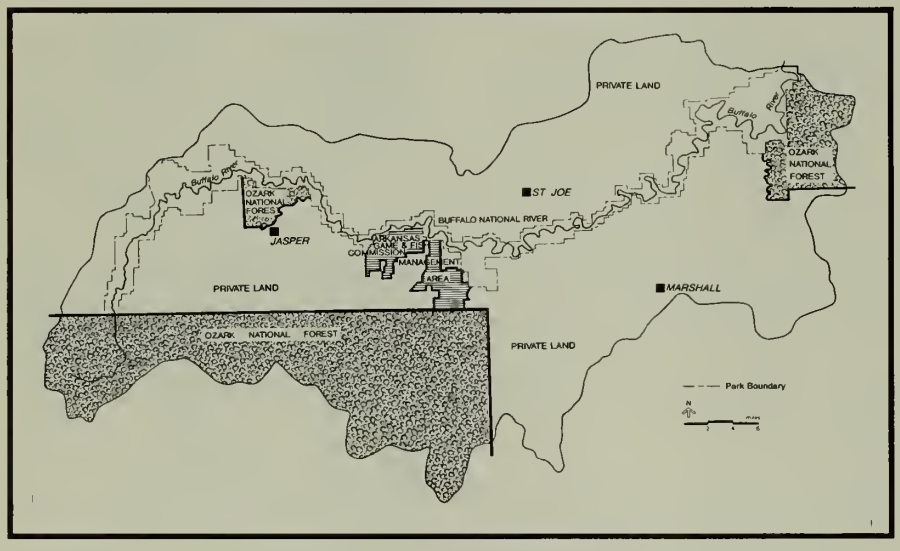
Buffalo River Watershed Students Get WET

By David N. Mott, Hydrologist, and Michael Naranjo, Biological Technician, Buffalo National River

Education is an important part of the stewardship of the Buffalo National River. The National Park Service manages only 11% of the total river watershed, sharing ownership with Ozark National Forest (26%), Arkansas Game and Fish Commission (3%), and many private landowners (60%).

Forest Service, National Park Foundation, Arkansas Department of Pollution Control and Ecology (ADPCE), and Arkansas Game and Fish Commission.

Teachers select gifted and talented students in grades 6 to 12 to participate. The program is long-term, emphasizing environmental



Buffalo River watershed, land ownership, and locations of WET programs.

Although the quality of the water flowing into and along the Buffalo River is generally considered excellent, the land use activities of these landowners (e.g., logging, gravel mining, agriculture) have been identified as affecting the river in some areas. With 60% of the watershed managed by private individuals, the future of the river may well be in their hands.

Educating the public provides one strategy for preserving the ecological balance of the river and its tributaries. Three schools within the watershed of the Buffalo National River have been chosen to take part in a pilot Water Education Team (WET) program. WET is sponsored by the National Park Service, U.S.

values and an understanding of the ecological balance of streams. Organizers hope the students will educate their parents and others.

In order to participate, participants attend two days of training. In the training sessions, students and teachers are treated equally. Both are taught about water as a resource, the three components of water quality monitoring (chemical, physical, and biological), and the methodology used for water sample collection, analysis, and recording. Experts and guests from various agencies and organizations participate in the sessions.

Monitoring stations along various tributaries are chosen based on accessibility and logistics, and sampled every month. Each school is equipped with field gear, meters, and lab equipment. In addition, the schools receive computers, software, and modems for networking and data entry.

Buffalo National River, Ozark National Forest, and ADPCE work closely with the schools to troubleshoot problems, replenish needed supplies, and analyze samples for nutrients. The students use EPA-approved methods to measure pH, dissolved oxygen, conductivity, temperature, turbidity, and fecal coliform bacteria, and to identify macroinvertebrates. Refresher training and quality control checks are provided annually.

The program has been a real success thus far. One senior demonstrated leadership and initiative by designing a sampling regime for additional sites on the Little Buffalo River, which received state recognition and a $1000 Future Farmers of America college scholarship.

Antietam Monitors Aquatic Resources

By Debbie Cohen, GIS Specialist, Antietam National Battlefield

Antietam National Battlefield is best known as the site of the bloodiest single-day battle in American history. On September 17, 1862, in the fields adjacent to the small town of Sharpsburg, Maryland, Union

and Confederate forces clashed mightily in one of the Civil War's most pivotal battles. After nearly twelve hours of savage fighting, 23,000 soldiers were either killed, wounded, or lost in action.

The battle ended as a tactical draw with neither side showing any clear advantage. However, Confederate forces withdrew the following day, and as a result, the battle was considered a strategic Union victory. That victory enabled President Lincoln to issue the preliminary Emancipation Proclamation.

Obviously, the historical significance of this National Park System site is clear. Therefore, the question becomes: Why should a park so richly steeped in historical context address the issue of water quality? The answer to this question is one of perspective and perception. In the greater realm, Antietam National Battlefield is comprised of many resources; predominantly historical, but cultural and natural resources, as well. As a result, the cultural landscape validates and reinforces the inherent historic significance of this site, especially from the visitor's point of view. It is the way these resources are integrated that makes Antietam one of the best preserved Civil War sites in the country.

The recognition of the importance of integrating all landscape features became the catalyst for designing an aquatic monitoring program. This program is called the Antietam National Battlefield Water Watcher program and is funded by a National Park Foundation grant. Although the program is primarily targeted toward students and scout groups, all visitors are encouraged to participate. It is a hands-on program in which participants test various physical, chemical, and biological parameters in order to determine a relative water quality measure.

Antietam Creek flows for two miles along the southern half of the battlefield and is the perfect laboratory for conducting this type of program. During the course of this activity, participants must resolve with several issues. 1. Does the aesthetic quality of the stream influence the overall visual quality of the landscape, and if so, how? 2. What factors determine water quality? 3. How does one obtain quantitative aquatic data? 4. How does one translate quantitative data into a qualitative measure?

The goal of this program is twofold: 1) foster a sense of appreciation for the resource in its total context and 2) provide a stewardship message about water quality that goes beyond the administrative boundary of the park to our collective backyards.

Video Describes Air Pollution in the Sierra

By Judith E. Rocchio, Air Quality Coordinator, Western Regional Office

A new video, "Payne's World on Air Pollution in the Sierra," takes off on "Wayne's World" to teach high school and junior high school students about air pollution in the Sierra. The video opens with two high school students looking for an interesting way to present their science fair project to their classmates. Both are having an identity crisis and want to avoid their "nerd" images. They come up with an idea: Why not make their presentation in an unusual but effective way, on video? "Today, Perth Amboy and Payne Stuart present the topic of Air Pollution in the Sierra via...Payne's World! Payne's World! Science Time! Excellent!"

Dressed up as "Wayne's World" characters, the two boys film their science fair project on video in the Amboy family garage. The set includes the "Perthmobile," a used car in need of repair as it produces a noxious exhaust. Perth inadvertently smokes out the garage, setting the stage for their excursion into the world of air pollution--Payne's World. During their presentation the two characters not only demonstrate they know a lot about air pollution, but that they are also a pair of hip rock'n'rollers.

During their investigation of the issue, Payne and Perth also discover solutions to the problem of air pollution. "The one thing we can all do to conserve energy is to turn off what doesn't need to be on. Mass transportation and bicycles are great ways to curb energy use, promote cleaner sources of energy like solar and wind power, practice recycling and reduced consumption. Use of proper insulation and planting of shade trees can really help in heating and cooling businesses and homes."

The video was sponsored by the Sierra Federal Clean Air Partnership, including the National Park Service, U.S. Forest Service, and U.S. Bureau of Land Management. It was funded by the San Joaquin Valley Unified Air Pollution Control District. Every high school and junior high school in the San Joaquin Valley will receive a copy of the video as well as a teacher's guide packet that includes demonstrations and activities to be carried out in class. The sponsors believe that using an innovative and humorous approach to teaching a complex issue will stimulate students to take personal actions and make commitments to improve air quality.

NPS Units Represented in the Highlights of Natural Resources Management Report

A. Antietam NP
B. Badlands NP
C. Bandelier NM
D. Bent's Old Fort NHS
E. Big South Fork NRRA
F. Buffalo NR
G. Canyonlands NP
H. Channel Islands NP
I. Denali NP&P
J. Dinosaur NM
K. Dry Tortugas NP
L. Glacier NP
M. Indiana Dunes NL
N. Lake Mead NRA
O. Oregon Caves NM
P. Presidio/Golden Gate NRA
Q. Rocky Mountain NP
R. Shenandoah NP
S. Theodore Roosevelt NP
T. Timpanogos Cave NM
U. Yellowstone NP

☆U.S. GOVERNMENT PRINTING OFFICE: 1995-0-676-004

As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the National Park Service.

Edited by Lissa Fox, Writer/editor, Wildlife and Vegetation Division. Additional publication services were provided by the Branch of Publications and Graphic Design of the Denver Service Center.

NPS D-1064 June 1995